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THE PLATTSMOUTH BRIDGE.

In previous numbers of the SUPPLEMENT* we have given accounts of this new and important structure, and we now subjoin additional particulars and engravings, which we take from the columns of our esteemed contemporary, the *Railroad Gazette*.

The Plattsmouth Bridge was built to connect the Chicago, Burlington and Quincy Railroad with the Burlington and Missouri River Railroad in Nebraska, which has now become by consolidation the Nebraska Division of the Chicago, Burlington and Quincy Railroad. The Burlington and Missouri River Railroad in Nebraska was built as an extension of the original Burlington and Missouri River Railroad (now the Iowa Division of the Chicago, Burlington and Quincy). The acts of the general government which provided for the construction of the Union Pacific Railroad, gave a land grant in Iowa and Nebraska to this line, the law providing that the Iowa road should be extended west, crossing the Missouri at some point below and near the mouth of the Platte, and thence to a connection with the Union Pacific Railroad east of the one-hundredth meridian

The Burlington and Missouri River Railroad in Iowa was opened through to the Missouri River in 1870. The construction of the Nebraska road west from the town of Plattsmouth, a mile below the mouth of the Platte, was begun a year or two earlier, and since 1870 connection has been made between the two roads by a transfer steamer belonging to the Nebraska railroad.

For several years serious trouble was experienced by the shifting channels and the difficulties of making the landings, the transfer landing being near to and above the town of Plattsmouth. These difficulties became so great that a new point of crossing was selected about a mile below Plattsmouth, where the channel had been more permanent than at points above, and where the west bank was a high bluff. Opposite this high bluff a dike was built, extending from the high water shore of the east side of the river out into deep water, for the double purpose of confining the river to a permanent channel and serving as an approach to the low water landing. This dike, built of brush and stone around a skeleton of pile work, settled and required considerable repairs from year to year, but was entirely successful for the purpose it was designed for, and has now become practically a permanent work. In the winter of 187?–79 the management of the Nebraska road found that their business had grown so large that it could no longer be satisfactorily accommodated by the transfer boats, and a temporary pile bridge was built, which was used during that winter, while it was recognized that the time had come when a permanent bridge must be erected. In February, 1879, the location of a permanent bridge was intrusted to Mr. George S. Morison, the engineer under whose charge the bridge has since been completed

* See SCIENTIFIC AMERICAN SUPPLEMENTS, numbers 239 and 271.

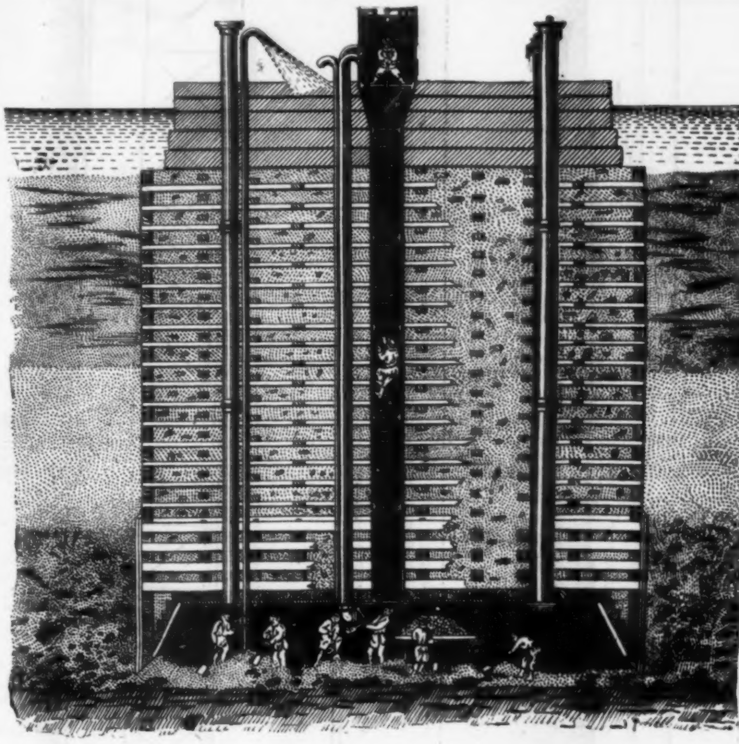


Fig. 4.

LOCATION.

The proper location for this bridge was really the chief problem in its construction. The Platte flows into the Missouri about a mile above the town of Plattsmouth, and is a disturbing element which at times attains a considerable magnitude. Opposite the town of Plattsmouth the high-water river is about a mile wide and the channel very variable, having

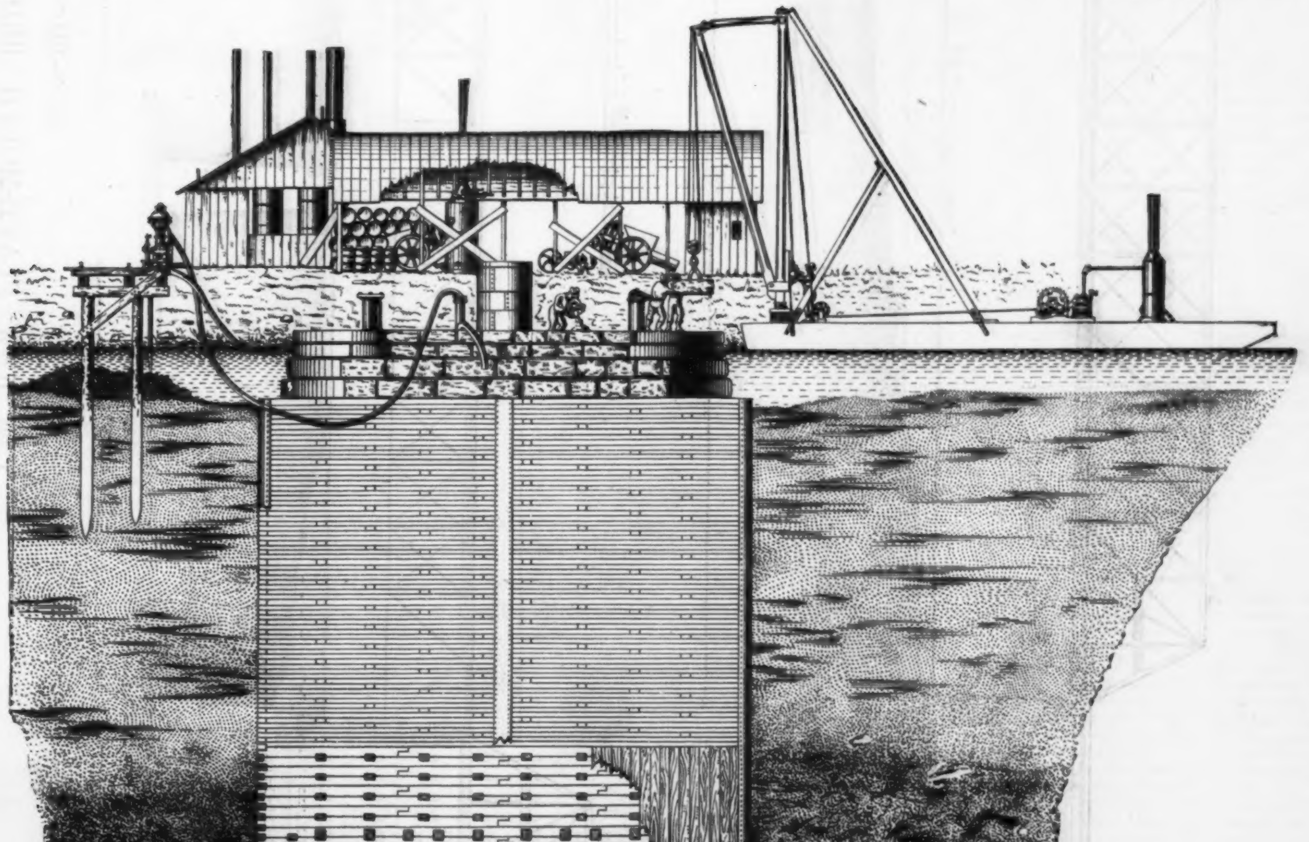
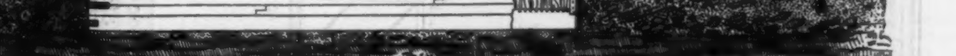


Fig. 3.



THE NEW PLATTSMOUTH BRIDGE OVER THE MISSOURI RIVER.

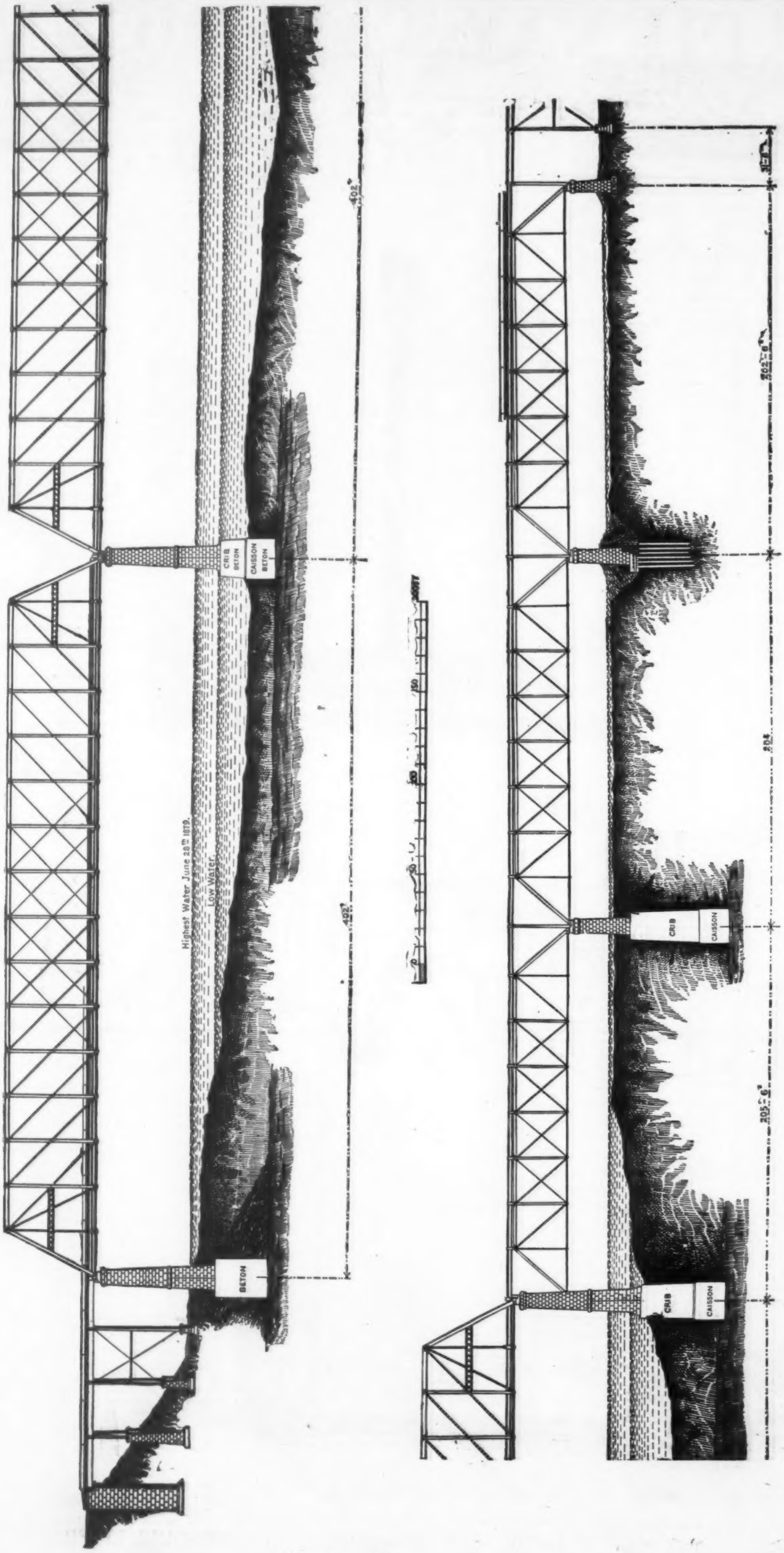
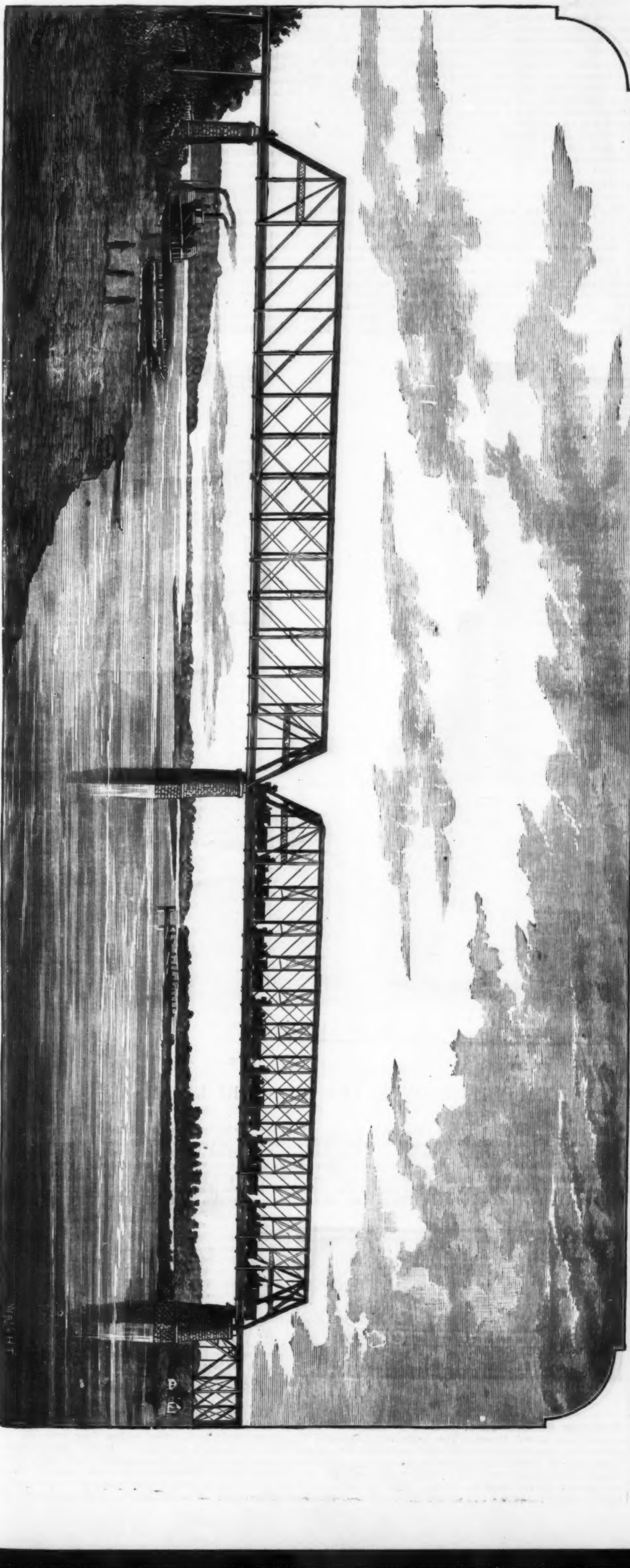


Fig. 2.—DIAGRAM OF BRIDGE.

THE NEW PLATTSMOUTH BRIDGE OVER THE MISSOURI RIVER.

THE NEW BRIDGE ACROSS THE MISSOURI RIVER AT PLATTSMOUTH, NEB.



THE NEW BRIDGE ACROSS THE MISSOURI RIVER AT PLATTSMOUTH, NEB.

within a few years been next to the east shore, next to the west shore, and about in the middle. At low water the river is confined to the width of the channel, the remaining portion being a dry sand bar (shown in the map, Fig. 1, on another page). At the point where the dike had been built this width is contracted to less than 800 feet. The contraction resembles the throat of an hour-glass, being drawn in on both sides by the bluff on the west and the dike on the east. The result of this configuration was that the channel was fixed with as great a degree of permanency as is ever found in the Missouri, in its position, but the direction of the current changes greatly according to the position of the channel in the broad river above. It was decided at once that the location of the bridge ought unquestionably to be a little below the dike at the point where the greatest permanency of channel had been established. The only objection to this location was the existence of a high clay bluff on the west approach, involving a deep and expensive cutting. The changeable direction of the current rendered the construction of a draw-bridge virtually out of the question, as it involved keeping the channel current parallel to the shore line and the draw-pier, and it was decided to adopt the high-bridge plan, which has generally met with more favor than the draw-bridge plan for bridges on the Missouri.

GENERAL DESCRIPTION.

The line selected for the bridge crosses the river about 500 feet below the dike, as shown in the map. The river at all ordinary stages, in fact for all stages except those of exceptional high water, is crossed with two spans of through bridge, each 400 ft. long, the bottom chord of which is placed 50 ft. above high water; the extreme rise and fall of the river is about 17 ft. On the east side are three deck spans (shown in Fig. 2), 200 ft. each, reaching across the sandbar, and beyond them 1,440 ft. of iron viaduct. On these deck spans and viaduct there is a grade of 0·5 in 100 descending eastward. From the east end of the viaduct the grade descends on an earth embankment at the rate of 1 in 100 to the level of the Chicago, Burlington and Quincy track on the Missouri bottom. The east approach is straight for about two miles. On the west side an iron viaduct 120 ft. long reaches from the main bridge to the beginning of the approach. This west approach begins with a 12° curve to the north, the short piece of viaduct being built on a compound curve connecting with this; the approach passes through a cut nearly 80 ft. deep at the deepest point, and thence along the face of a clay bluff to Plattsmouth station, its length being just one mile. The grade of the straight portions of this line is 45 ft. per mile ascending eastward, compensated for curvature and reduced to 13 ft. per mile on the 12° curve.

The bridge proper is just 3,000 ft. long from outside to outside of abutments; the main structure 804 ft. long from center to center of piers Nos. I. and III. The foundations of these three piers rest on bed rock at depths varying from 30 to 50 ft. below extreme low water. The foundation of pier No. IV., the pier east of the east large pier, is also carried down to rock. Pier No. V. has a pile foundation; all other masonry, being well back from any chances of scour, is founded on concrete.

TIME.

It was not until June 30, 1879, that the directors of the Nebraska road finally determined to build the Plattsmouth Bridge. About two weeks were necessarily consumed in getting an engineering party on the ground, and it was not till the latter part of July that work was actually begun. The regimen of the Missouri River is such that this late commencement seriously enhanced the difficulties of the work. The best three months in the year for work in the river are September, October, and November. The most important point was to get the foundations in as quickly as possible, and there was not sufficient time to procure a new outfit and organize a proper force. One of the first things done was to close a contract with Gen. Wm. Sooy Smith, who had just completed the Glasgow bridge, for the pneumatic work of the foundation of piers Nos. II. and III., using the same machinery and the same force of men which had been used at Glasgow. This contract was subsequently extended so as to cover pier No. IV. Contracts were also let for the masonry and the approaches as early as possible.

FOUNDATIONS.

The foundation for pier No. I., the pier at the edge of the west shore, was put in with an open pit, the sides being protected by ordinary sheeting. An unexpected difficulty occurred at this point. Borings carefully taken over the whole site of the pier had found rock at about low-water level. The solid character of this rock had been established by drilling into it two and a half feet, and its existence was corroborated by the testimony of men engaged on the river, who said they had seen it at extreme low water. When this rock was reached it was found to be really a mass of bowlders from 4 to 6 feet thick, so closely packed that the drill holes had passed from one stone to another without detecting the crevices and many of the rocks were so large that they could only be removed by blasting. Below these bowlders was found a mass of stratified shale, which had evidently never been disturbed. The excavation was carried through this shale to a depth 28 ft below low water, where a flat limestone bed rock was reached. To render the work doubly secure against a possible slip in the shale, 160 holes 18 in. deep were drilled into this rock, in each of which a dowel of 1¼ in. iron was placed. The pit was then filled with Portland cement concrete to the low-water level, and on this concrete the masonry of the pier was started. This concrete, as well as all other concrete in the deep foundations, was manufactured by Dr. J. C. Goodridge with the French mixing machine designed by M. Coignet.

The foundations for piers Nos. II. and III. were put in by the plenum pneumatic process. The caissons (Figs. 3 and 4) were 51 ft. long and 21 ft. wide, built of pine timber, lined with plank well calked, and sheathed on the outside with two courses of 3 in. plank, the inside course being put on diagonally. The design of these caissons differs somewhat from the form of caisson which has been hitherto used; the outer walls were built of 12x12 in. square timber, and the side walls of the working chamber, which were made of the same sized timber, inclined inward from the cutting edge. The roof was made of a single course of 12x12 in. timber surmounted by about 8 ft. of cribbing, the caisson being 16 ft. high, including the cribbing. The entire space above the roof of the working chamber was filled with concrete, the mass extending down into the V shaped space in the side walls, and interlocking with the crib work in such a way that comparatively little of the weight came directly on the roof of the working chamber. The timbers of the successive courses were fastened together with drift bolts 30 in.

long, and the whole caisson was bound by long iron bolts extending through the whole height of the sides at the corners and the intersecting points of the cribbing. The reason for adopting this plan of caisson instead of the more usual plan in which a thick timber roof is used, was to secure at once the greatest possible combination of strength and weight, so as to sink the piers to the bed-rock by steady pressure instead of by occasionally blowing off the compressed air, thus reducing to a minimum the risk of of over-straining the work and breaking the bond in the masonry. The success of this form of caisson was complete.

The caissons were built on shore, launched and towed into position. That for pier No. III. was built first. The pneumatic machinery was erected on the east sand-bar near pier No. III., and the air and water were led to the sites of the piers in pipes. The sand was generally excavated by the use of the Eads sand pump, the water being supplied by a No. 8 Cameron pump. Before work was begun at pier No. II. a temporary bridge was built from the east shore to the site of the pier, which served for transportation of material and to carry the pipes. This service bridge was built in connection with a temporary bridge used for the transfer of cars.

The masonry was started a little below extreme low water; the space between the top of the caisson and the masonry is occupied by crib work made of 6x10 in. pine timber, laid flat and filled with Portland cement concrete. The superior excellence of the concrete used makes the foundations probably stronger than if built of ashlar masonry.

The foundation of pier No. IV. was likewise put in by

SUPERSTRUCTURE.

The superstructure of the Plattsmouth Bridge may be divided into three parts; the iron viaduct, the check spans, and the channel spans. The two former are entirely iron, the last largely of steel. The general specification on which the entire superstructure was proportioned provides for a uniform moving load of 2,000 lb. per lineal foot, preceded by two locomotives, each weighing 150,000 lb. on 50 ft., the additional 50,000 lb. of locomotive weight being supposed to be concentrated on a length of 20 ft. The structure is also designed to resist a lateral wind pressure of 500 lb. per lineal foot on the floor, and 200 lb. per lineal foot on the top chord of the through spans and the bottom chord of the deck spans. These quantities are about equivalent to a wind pressure of 30 lb. per square foot on the bridge when covered by a train, and to 50 lb. per square foot on the empty bridge.

VIADUCTS.

The iron viaducts consist of forty-eight spans of 30 ft. each at the east end of the bridge, and four spans of 30 ft. each at the west end. The design is that of riveted plate girders resting on wrought iron posts. The girders are 38 in. deep, and spaced 9 feet between centers, each girder consisting of a ⅜ web-plate, and four angle irons, two in each flange. They are connected by stiffening frames 10 ft. apart, with diagonal rods for lateral bracing above and below. Each iron post is composed of two 9-in. channels and a plate, the section of the post being 13¼ square inches. The posts have a batter of 1 in 8, two posts forming a bent, exerting on a single pair of bents a horizontal pull of 25,000 lb., this being the estimated adhesion of an engine carrying 100,000 lb. on its driving-wheels. The character of the floor system is such that it is not believed that this strain will ever be realized.

The entire viaducts are of wrought iron, except the bed-plates between the wrought iron posts and the masonry, which are cast. The whole length of the viaduct at the eastern end of the bridge (1,440 ft.) was erected in two weeks. It is built on the grade of 1 in 200.

DECK SPANS.

There are three deck spans, each 200 feet long, between the centers of end pins. The trusses are 30 ft. deep and 16 ft. apart between centers. Each truss is divided into eight panels of 25 ft. each, the general design being that of a single system Pratt truss with inclined end posts. The floor system rests on the top chord at the panel joints, and consists of riveted cross-floor beams, with longitudinal stringers; the stringers are placed 9 ft. apart between centers, and riveted to the webs of the cross-bearers; each stringer consists of a ⅜-in. web-plate and four angles; they are connected by a stiffening frame at the center of each panel, with diagonal lateral rods. The flanges of these stringers are identical with those of the viaduct, so that the floor is practically uniform throughout. The grade of 1 in 200 on the east viaduct is continued across the deck spans; the trusses are built level, each span being placed one foot higher than the span east of it, and the grade is then pro-

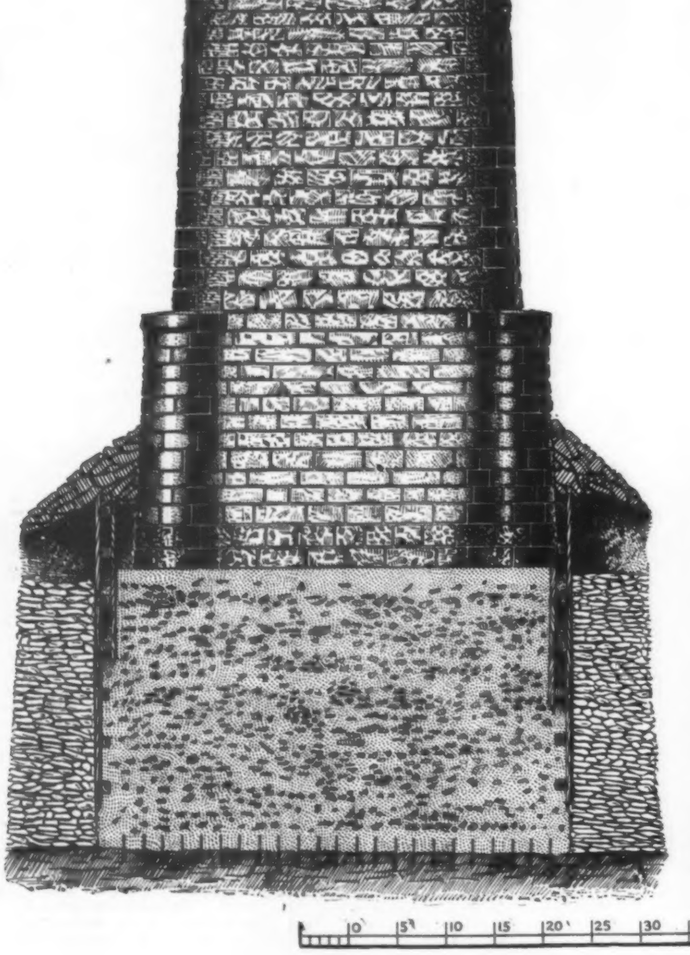


FIG. 5.

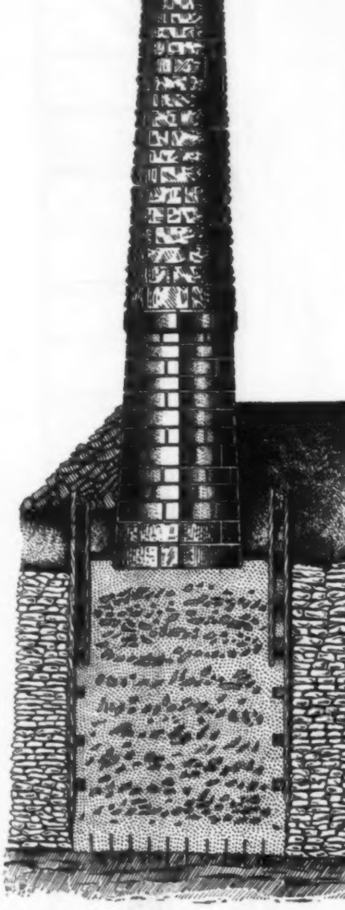


FIG. 6.

THE NEW PLATTSMOUTH BRIDGE OVER THE MISSOURI RIVER.

the pneumatic process, but the caisson is considerably smaller and constructed on a much less perfect plan.

The piles for the foundation of pier No. V. were driven with a 3,800-lb. hammer, and have an average penetration of 28 ft.; they were driven in an excavation made inside a timber curve, and are cut off about 3 ft. below extreme low water. Pier VI. has a concrete foundation, as have also the small piers under the viaducts.

MASONRY.

A small portion of the masonry, including the whole of pier VI., is built of stone taken from a quarry on the Platte River, about twenty-five miles from the bridge. The remainder of the masonry, except that under the viaducts, is built of stone brought from the Cottonwood quarries in Central Kansas. This stone is a magnesian limestone of the best kind, which works easily and has unusually good beds. All the first-class masonry is laid in Portland cement mortar.

The form of the three principal piers (Figs. 5, 6, and 7), from low water to a height of about 7 ft. above high water, is that of a pier with straight sides, brought to a point at each end by circular arcs having a radius of about three-quarters the thickness of the pier. The piers have a batter of 1 in 24 throughout. This form is believed to be that best adapted to the conditions of the Missouri River, which carries large quantities of driftwood. On the upper parts of the river greater precautions would have to be taken to resist ice. The three principal piers finish 8 ft. thick and 33 ft. long below the coping, having a minimum sectional area of 250 square feet. The cutwaters and copings of these three piers are dressed smooth; the rest of the masonry has a rough quarry face.

At the base the iron posts rest on small piers of masonry. These piers are 3 ft. square, with a concrete foundation 5 ft. square, 7 ft. below the surface of the ground. Each post is anchored to the masonry by a 1⅛ in. rod, extending through the entire masonry into the concrete foundation. The posts of the bent are connected by transverse struts at the center and top, with diagonal rods between. There is no strut at

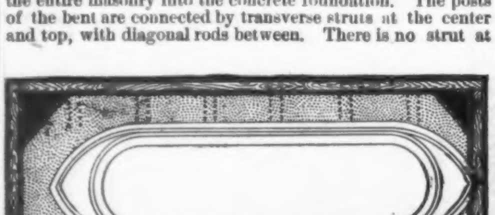


FIG. 7.

the bottom, the anchorage of the masonry being relied upon to resist any lateral thrust. The bents are connected together in pairs by bolting the girders to the top of the posts, and by longitudinal struts half way up. They are braced longitudinally with rods which couple on a pin passing through the center of the struts. This bracing is calculated to resist the thrust due to the action of a locomotive

vided for by varying the depth of the cross-floor beams at the ends, where they rest on the chords.

These three 200-ft. spans are entirely of wrought iron, except the pins, which are of steel. They rest upon heavy cast iron pedestals anchored to the masonry. The west end of the west span has a bearing in niches left in the masonry on the east side of pier III.

CHANNEL SPANS.

The channel spans are two in number, each measuring 400 ft long from center to center of end pins, the total length from center to center of piers being of 402 ft. The details of these spans are shown by Fig. 8. The trusses are 50 feet deep, and placed 22 ft. apart between centers. Each span is divided into sixteen panels of 25 ft. each, and the general design is that of a double system Pratt truss with inclined end posts.

In these two channel spans the floor, the intermediate posts, the lateral struts, the vibration rods, and vertical suspenders in end panels, the portals, and all nuts of every kind, except the jaw nuts on the bottom chord pins, are of iron. The top chords, the end posts, the tension members, the pins, the bolsters, the rollers and bearing plates, and the jaw nuts are of steel.

The top chords and end posts are riveted steel members formed of plates and angles, and measuring twenty eight inches wide by nineteen inches deep over all, the under side being open and laced. In the manufacture of these pieces the steel was first punched with three-quarter inch holes, then assembled, and the holes reamed to one inch, and then riveted without taking apart, the rivets being of low-carbon steel. The maximum compressive strain allowed to

these members is 15,000 pounds per square inch, the sections being so proportioned as to carry this strain on the two side pieces of the member, the central part of the top plate being relied upon only for lateral stiffness. The connection between the top chord and the end posts, and between the end posts and bolsters, are pin connections, all parts being entirely of steel. On these pins the pressure per square inch measured on the diameter and not on the semi-intrados, is limited to 20,000 pounds per square inch.

The steel bars in the bottom chord and the main ties were rolled by the Kloman process in a universal mill, the motion being reversed while the bar is still between the rolls, the heads being subsequently forged into shape with a steel hammer, and the whole bar afterwards annealed. Of seven full sized bars which were tested to breaking, not one broke or showed any weakness in or near the head. Fig. 9 is a diagram of strains of these spans. The maximum strain allowed on steel in tension is 15,000 pounds per square inch, this occurring only in the middle panels of the bottom chord and being reduced to 12,500 in the end panels; in the web the strain per square inch varies from 10,000 pounds per square inch at the center to about 12,500 pounds in the end ties, except under the extraordinary supposition of the entire weight on the driving wheels of two seventy-five ton locomotives being carried entirely by the same system; in this case the maximum strain on the end attachment. Between the two inclined end posts is placed a wrought-iron riveted portal, the sides of which are extended to the level of the floor. The end posts are also stiffened by longitudinal struts connecting them with the centers of the first vertical posts, which are rigidly held by the central pin connections.

The floor stringers are precisely the same as those of the deck spans. They are attached to the web of the transverse floor beams, and the floor is practically uniform with that of the deck spans and the viaduct. All lateral rods are placed in pairs, as are also the wind-bracing rods between the intermediate posts. The connections are everywhere made on turned steel pins, the holes in the rods being accurately bored and the rods being tightened with sleeve nuts. The lateral pins pass through the main pins, excepting on the bottom chords, where the connection is made with steel jaw nuts.

In the design of these trusses, care was taken to secure uniformity in sizes. All the pins except the lateral pins are of the same diameter, 4$\frac{15}{16}$ inches.

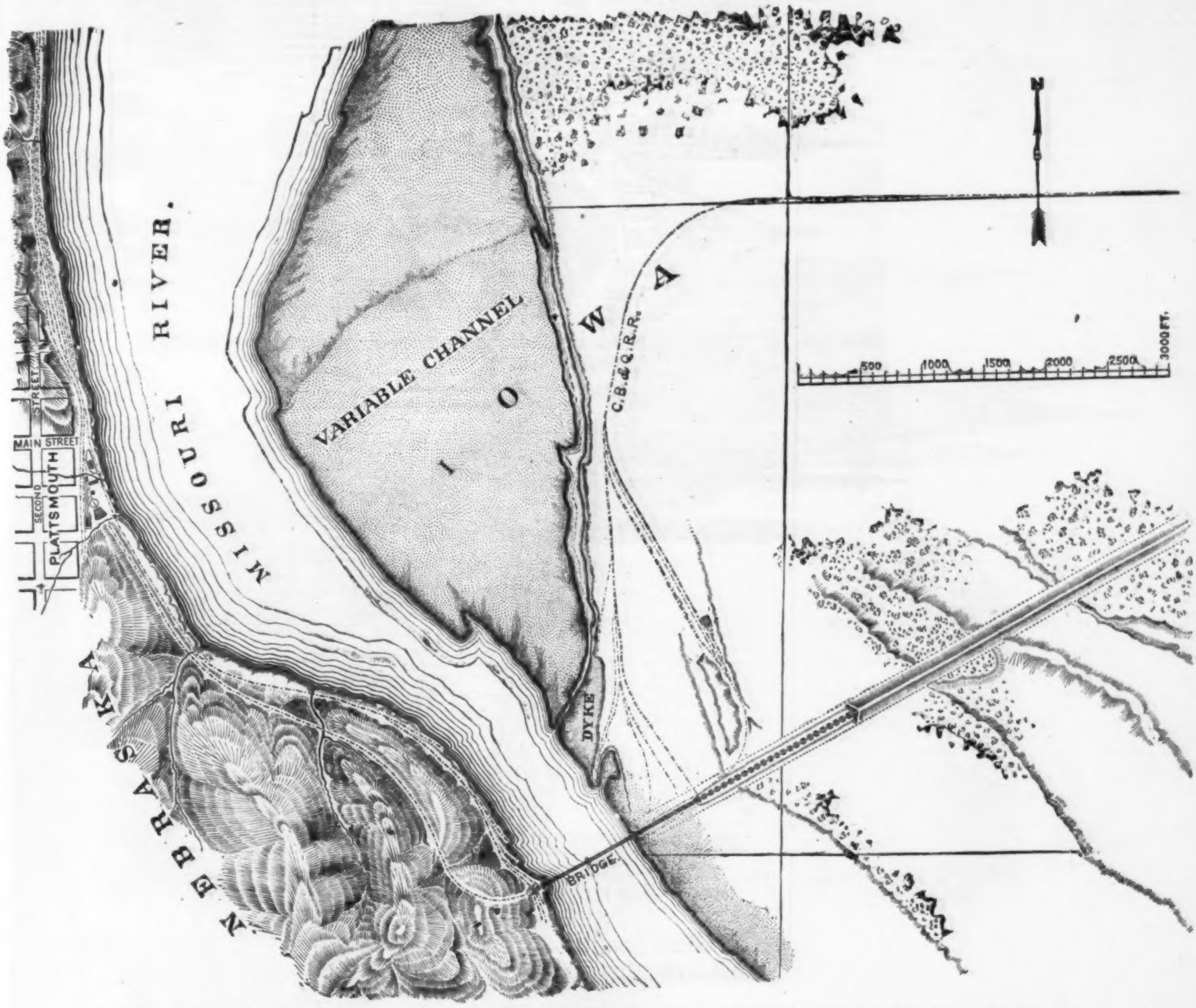
STEEL.

The steel used in the Plattsmouth Bridge was manufactured by Hussey, Howe & Co., of Pittsburg, in an open-hearth furnace. The specifications required that a sample (about $\frac{5}{8}$ inches diameter), should be taken from every melt, and that this bar should bend cold 180 degrees around its square and sized down one inch over each tie; the guards are ten feet four inches apart in the clear, and fastened with a one inch bolt to every fourth tie. Inside the rails are placed two lines of 4 x 5 inches angle iron, with the long side flat, laid to a gauge of three feet eight inches over all, and bolted to every tie with a one inch bolt; this arrangement leaves a space of 6½ inches between the angles and the rail, which is wide enough for a derailed wheel to travel in. The nuts are on the upper ends of all the bolts, so that they can readily be tightened by a bridge watchman.

Every fourth tie is sixteen feet long projecting two feet on the outside of the ribbons, and on the projecting ends is laid a foot-walk composed of two lines of 2x10 inch oak plank. Every twentieth tie is eighteen feet long, projecting one foot on each side of the footway, and carries a wrought iron stanchion through the eye, at the top of which is passed a three-quarter inch wire rope, which serves as a hand rail.

At the west end of the bridge, where the short piece of viaduct is on a sharp curve, the ties are 9x12 inches, and sized to give a slight elevation to the outer rail.

Ties of the same dimensions as those on the bridge are laid across the masonry of the abutments, and on these the ends of the guard angles are brought together in a point (see Fig. 13) in the center of the track by pieces of four inch oak plank cut to shape, bolted to the ties and plated on the face with a wrought iron strap.



MAP SHOWING THE LOCATION OF THE PLATTSMOUTH BRIDGE OVER THE MISSOURI RIVER.

of the diagonals will slightly exceed 14,000 pounds per square inch.

The counter ties and lateral rods are also of steel. The counters are flat and were rolled in the same manner as the main ties. The laterals are square, and were rolled in the same mill between grooved rolls, the bar being run through to the head, the mill reversed and the bar run entirely out, and subsequent passes being taken in a similar manner between smaller grooves; the screw end was then enlarged by upsetting and forged down. The strain on counters is always less than 10,000 pounds per square inch; that on the laterals is limited to 22,000 pounds. Tests made of these light steel bars showed a superior proportional excellence fully equal to that commonly found in small sections of wrought iron as compared with large sections.

The intermediate posts are of wrought iron, each post consisting of two channels laced at the sides. Each post has three pin connections; at the top with the top chord, at the bottom with the bottom chord, at the center with the diagonals, each diagonal being made in two lengths and coupling on to this central pin. This arrangement holds the post rigidly at the center, supports the diagonal from sagging, and proved in every way a satisfactory detail. These intermediate pins are connected with transverse struts between opposite posts of the two trusses, with wind bracing diagonal rods between these struts and the top lateral struts. The tranverse floor beams, which are thirty-nine inches deep, are riveted to the sides of the posts, forming a rigid own diameter without cracking; that it should have an elastic limit of at least 50,000 pounds, and an ultimate strength of at least 80,000 pounds; and that it should elongate twelve per cent. before breaking, and show a reduction of twenty per cent. at the point of fracture. The percentage of carbon was fixed at 0·35.

A difference in the strength of small and large-sized bars corresponding to that which exists in iron bars was found in the steel. The finished bars measured 6 x 1¼ inches to 1⅝ inches; when tested in the government machine at Watertown, were found to have an elastic limit of 37,000 pounds, and ultimate strains of from 66,000 to 73,000 pounds. The modulus of elasticity below the elastic limit was exceedingly uniform. Smaller sizes, used in counters and laterals, approximated closely in their strength and elastic limit to the test samples.

FLOOR.

The construction of the floor of the Plattsmouth Bridge is shown by Figures 10 to 13. It is uniform from one end of the permanent structure to the other. It is so designed that it is believed it could safely carry a derailed train for any distance.

The iron stringers are placed nine feet from center to center. On these stringers rest oak ties nine inches square, and generally twelve feet long, these ties being only six inches apart in the clear. The ties are held in place by two oak guard timbers or ribbons, these timbers being ten inches

The following are the names of the engineers employed on this work:

Chief Engineer, George S. Morison; First Assistant Engineer, stationed at Plattsmouth, Henry W. Parkhurst; Assistants, Benjamin L. Crosby, W. G. Dilworth; Assistant Engineer of superstructure, C. C. Schneider; Inspectors, Jacob Jung, A. Lavandeyra; Draughtsman, S. W. Y. Schimonsky.

The principal contractors engaged in this work were the following:

Masonry, Reynolds, Saulpaugh & Co.; Concrete, J. C. Goodridge, Jr.; Pneumatic foundation works, Wm. Sooy Smith.

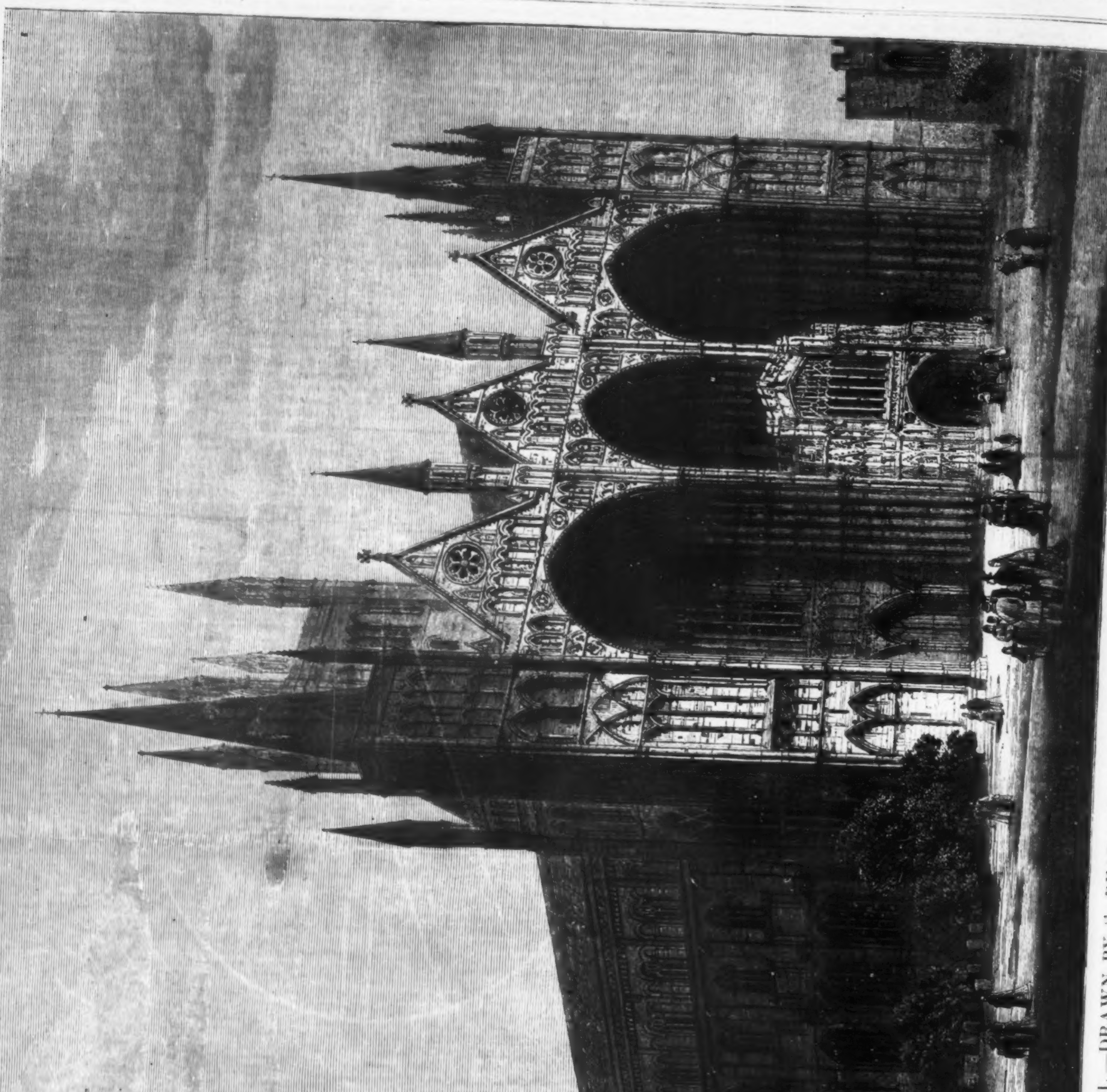
Superstructure of 400 foot spans, Keystone Bridge Co.; Foreman of erection, W. Baird.

Viaduct and 200 foot spans, Kellogg and Maurice; Foreman of erection, J. B. Ryland.

Grading of approaches, N. S. Young; enlargement of west approach and filling temporary trestle in east approach (this work not yet completed), S. Dwight Eaton.

KILLING WEEDS.

THE plants should be cut off close to the ground and a few drops of coal-oil poured on to the crowns. They immediately commence to decay and are utterly destroyed. Troublesome weeds on the lawn can thus be speedily disposed of, but others will likely take their place.



PETERBOROUGH CATHEDRAL.—DRAWN BY S. READ. FROM THE ILLUSTRATED LONDON NEWS.

PETERBOROUGH CATHEDRAL.

THE Saxon Chronicle informs us that, in the year 655, Oswy, King of Northumbria, having defeated and killed the heathen Penda, King of Mercia, this event produced the Benedictine monastery of Peterborough the first that was erected in the midland and east-midland shires of England. Peada, the son of Penda, had embraced the Christian religion, and was permitted by Oswy to reign in Mercia in his father's stead. He founded this monastery, as he was bidden by Oswy to do, choosing a site at Medeshamstede, on the river Nene, in North Gyrwa-land overlooking a wide expanse of fen country to the east of Northamptonshire. The two kings, with their own hands, "began the ground wall and wrought thereto." The brother of Peada, Wulfere, who succeeded him three or four years later, and Ethelred, the next King of Mercia, continued to favor the rising monastery. It was completed, and was dedicated to St. Peter, St. Paul, and St. Andrew, by the Archbishop of Canterbury, the Bishop of Rochester, and other prelates. The first Abbot was Saxulf, who became Bishop of Mercia in 674. Great privileges and high precedence were conferred by the Pope on this monastic establishment. It was sacked and destroyed by the Danes, under Hubba, in 870, but was rebuilt by Athelwold, Bishop of Winchester, in 966. From that time it was called Peterborough, and the epithet of "Golden" was added, from part of the Minster roof having been gilt by Abbot Leofric, a relative of King Edward the Confessor. This prelate was a mighty pluralist, holding five monasteries at once—Burton, Coventry, Crowland, Thorney, and Peterborough. His successor, Abbot Brand, was uncle to Hereward the Saxon, and knighted that champion, who nevertheless did not scruple to drive out the Norman Abbot Thorold and carry off the relics and treasure of this wealthy monastery.

The Abbots of Peterborough lived in great prosperity through the Norman, Plantagenet, and first Tudor reigns, became immensely rich, and built what is now the Cathedral. Its present choir was begun in 1116, by Abbots John of Seez and Martin of Bec; the transept and nave are later Norman, by Abbots William de Waterville and Abbot Benedict. The Early English west front, with its three grand arches forming a magnificent porch, was probably built from 1200 to 1222, by Acharius and Robert of Lindsey, successive Abbots; it seems coeval with the west porch at Ely and the chapter-house at Lincoln. These arches are 81 ft. high, supported by triangular piers, entirely detached from the west wall; and they are flanked at each side by a square turret, with spire and pinnacles, to the height of 156 ft., which is equal to the length of this façade; the arches support gables, each holding a circular window, and all the details are very noble and graceful. This is the unique and most characteristic feature of Peterborough Cathedral, which is seen very well from the Great Northern Railway trains at the station there. The later portion of the building is the east aisle, of Perpendicular architecture, commenced by Abbot Ashton, in 1438, and completed by Abbot Kirton from 1496 to 1528.

The last Abbot, John Chambers resigned this place to King Henry VIII. in 1540. As Queen Katharine of Arragon had been buried here in 1535, the church was spared, and became the Cathedral of a new bishopric, to which the late Abbot was preferred. Mary Stuart, Queen of Scots, was also buried here in 1587, after her execution at Fotheringay Castle, but her body was removed to Westminster Abbey in 1612.—*Illustrated London News.*

BUILDING CONCRETE WALLS.

C. B. V. asks me to give the mode of building these walls, and whether they will stand for 10 or 15 years; masons tell him they are cheap, and that not much must be expected of them.

Knowing of this little piece of advice, so often given by the masons about what they have no practical experience with, I am led periodically to give practical instruction on this important economy to farmers. The masons admit that the concrete wall is cheap, but this admission is wholly an inference on their part, from the fact that farmers who build it are able to do so without their assistance, and they thus infer them to be short lived. Had they studied their business as becomes master mechanics, they would know that the materials of a concrete wall are as durable and well adapted to the purpose intended as the materials out of which they build walls, and that their cheapness consists in saving the entire mason's bill, because the helpers who attend upon the masons can build this wall in less time than masons and helpers can build the ordinary mortared wall. We have a section of this wall that was built 23 years ago, stood an intense fire seven years ago, and has since stood in the open air, still remaining firm. We have also a concrete wall under a house 12 years old, and stronger now than when built, because much harder. The wall under my 80 foot octagonal barn, with a capacity of 200 tons of hay and 3,000 bushels of grain in the straw, having a basement 8½ feet in the clear, is only 15 inches thick at the bottom and 12 inches at the top; whereas many smaller barns, with stone walls, built by masons as their judgment dictated, are two feet thick. My wall has stood the heavy winds upon the barn for six years without a crack, and is to-day as solid as a rock, and cost 10 cents per cubic foot complete. If the well built concrete wall requires only about half the thickness of a mason-built stone wall, it don't look as if the concrete wall needed any apology.

The great economy of the concrete wall is: 1. Not that the materials are cheaper (except that any rough stones may be used), but that any farmer can build it for himself, and it requires no outlay except for the lime. 2. As a basement wall it is greatly superior to a mason-built stone wall, because, first, it is air-tight; second, it is a poorer conductor of heat and cold, and consequently renders the basement drier and warmer—no frost ever appearing on the inside. It is certainly admirably adapted for basement stables and silos.

Water-lime is, however, somewhat more expensive than quicklime; but as only one barrel of cement, in most cases, is required for 40 cubic feet of wall, and at $1 per barrel will cost only 2½ cents per cubic foot, it makes a very cheap wall to the farmer who hauls his own sand and stones, and performs his own labor, as the cement would cost for a basement under a 30 by 40 foot barn only $27. But after the bottom layer is laid, part quicklime may be used, and reduce the expense somewhat for lime.

PREPARING TO BUILD CONCRETE WALL.

The method of building concrete wall is to set standards on each side of the proposed wall, to hold the boxing planks. Each pair of standards is placed three inches farther apart than the wall is to be thick—that is, if the wall is to be one foot thick, place the standards 15 inches apart; then two 1½-inch boxing planks, 14 inches wide, placed inside the standards, will leave a space of 12 inches between them. These pairs of standards are to be placed all around the proposed wall, about 8 feet apart if the planks are 16 feet long, or if the planks are no longer than 10 feet, then a pair of standards at each end will do, with a clamp across the upper edge of the boxing planks in the middle. These standards are held together by a lath nailed under the lower ends which will hold them in position, the lath remaining under the bottom of the wall when the standards are removed. The standards may be 3 by 4 inches scantling, and some 8 inches longer than the height of the wall. A bracket is nailed across the top of the standards, holding them the same distance apart at top, unless the wall is to be thicker at the bottom, in which case the outside standard should be set plumb and the inside standard drawn in at the top to give the required thickness to the wall. Each pair of standards should be plumbed in position, and then stay-lathed firmly to keep them in this position till the wall is built. When the standards are set all around the proposed wall, and the boxing planks are put in, so as to make a continuous box around the building, with the door frames set in the proper place between the boxing planks, the jams being wide enough to reach across the wall, then everything is ready for the concrete.

PREPARING THE CONCRETE.

The lower tier of the wall is best made wholly of water-lime concrete, compounded as follows: Mix well together one part of Akron or Rosendale cement with three parts of fine sand, both being dry. Now mix in four parts of coarse gravel (if you have it), and then mix the whole into thin mortar. Place a layer of this mortar two or three inches thick in the bottom of the wall box, and if you have cobble, rough, or any irregular stones, picked from the field, bed these in the mortar, taking care not to let them come quite out to the boxing planks. Use all the stones you can get in with a layer of mortar between them; tamp all down solid so as to leave no spaces unfilled. Fill in this way to the top of the boxing.

The next layer of the wall, and all above, may be proportioned as follows: One part of cement with six parts of sand, while dry. Mix in also six parts of gravel, in manner as before. Have a vat of quick-lime, well slaked under water, convenient, and use this thin milk of lime to wet up and mix into mortar the water-lime, sand, and gravel. This liquid quick-lime may be mixed into the mortar so as to get about one part of dry lime to eight parts of sand; and being so thin may be completely mixed through the mass of mortar. The quick-lime should be slaked under water several days before using. This quick-lime will improve the walls, and when hard will be water proof. This will give, if stones are also used, about one part of water-lime to 12 or 14 of sand, gravel, and stone, and one of quick-lime to 15 or 18 of other materials. This compound concrete will be cheaper than one of cement alone. The writer has built with this described mixture and found it very satisfactory—the wall becoming very hard in a few months.

When the first tier of the wall is completed, you go to the section of the boxing first filled and raise these boxing planks 12 inches, leaving a lap of two inches on the wall below. The second tier is then begun and filled in the same manner as the first, and so tier after tier, the boxing being raised 12 inches each time.

CONCRETE WALLS UNDER OLD BUILDINGS.

This wall is peculiarly adapted to old buildings, because of its convenience. When old buildings are raised and ordinary walls put under them, the shores or blockings are much in the way, and the holes left by them must be filled afterward. But in putting a concrete wall under them these shores are not in the way at all. Raise the building to the height desired, level it on the blockings, then place 3 by 4 scantling plumb under the center of the sills, wide way lengthwise of the sill, in sufficient number to support the building exactly in position; brace these firmly from the top, and then take out the blockings. Now place the standards and boxing around the building so to make a wall 12 inches thick, or 14 inches at bottom and 10 inches at top. These shores, supporting the building, will be in the middle of the wall box. Build the wall around them. The wall will not be injured by their rotting. This wall can be built under old barns so cheaply that few can have any valid excuse for keeping their stock in cold stables. By raising up the barns and putting their stables in the basement, they greatly enlarge their space for storing crops.

It is not at all necessary to have a side hill for a basement stable, and it is never best to go much into the earth, for stables should be dry and very light. But the farmer will always be well paid to raise a good, broad driveway into the upper story on both sides of the barn. If the basement goes even 18 inches below the surface of the earth, this soil scraped from the sides will build a good solid driveway into both sides of the second story. And the labor of building these driveways of earth is greatly exaggerated. A few days with a team and scraper will do it, and it will always remain in good order after a little gravel is put on top. On the sides where these driveways are made, it is well to place a tier of cobble stones against the wall, and then place against these any old rails or poles, and let the earth come against these rails, so as to have an air space between the earth and the wall, giving it time to become hard. Let the basement be well lighted—as well lighted as the sitting-room in a house.—*E. W. S., in Country Gentleman.*

WORK OF THE SCULPTOR.

A MAN wearing a high white cap and an apron, brandishing a chisel in his left hand and a mallet in his right, and striking off chips from a huge block of marble which represents the future statue—this is the idea that many people have of a sculptor. The real sculptor when at work will be found to be a man with hands as dirty as those of a boy making mud pies, who is cutting, punching, and smoothing a mass of soft clay. There may not be a fragment of marble in the studio, for with marble the sculptor has practically little to do. His work is generally in clay, but sometimes in plaster.

The clay used in most of the studios in this city comes from New Jersey. The Terra Cotta Company at Perth Amboy mixes the clay with water, and allows it to run out into broad pans. The gravel and stones sink to the bottom, the water evaporates, and the upper layer of the clay is used for purposes of sculpture. There is a place in Little Twelfth street, in this city, where sculptor's clay is said to be prepared by a grinding process in a mill. It is then mixed with water, and finally allowed to harden in cakes which are sent to the studios. The sculptor, chipping off pieces from a cake of clay, mixes them with water and works the mass until the whole, though still thick and tenacious, becomes soft and is readily moulded. This is his material. If a bust is to be done, a large mass of clay is roughly piled upon the flat top of a high stand, and fashioned into the rude likeness of a head. The implements used are the fingers and a kind of spatula made of wood, sometimes ebony, pointed and curving at both ends, so as to present a convex as well as a concave surface. Then the process becomes more delicate, and the sculptor's art is put to the test. Studying intently the face of the sitter, the sculptor pares away little bits of clay, here indicating a line and there a prominent bone or muscle, striving to catch the characteristic expression of his subject and to avoid making the bust appear heavy and wooden. If pressed for time the sculptor occasionally takes measurements of the sitter's head to assist in the work, but oftener he depends entirely upon the eye.

If a statue is to be modeled the clay requires support, which is obtained by plastering it upon a framework of strong wires or wood. The clay, which is constantly kept wet by being sprayed with water and wrapped in cloths, is more likely to crack, however, when it is kept in position by a framework. Modeling is sometimes done in plaster, which offers certain disadvantages on account of its hardening rapidly and tending to give a dull, lifeless expression to the face of the bust. In plaster modeling, as sometimes in working with clay, *ébauchoirs*, pointed iron instruments varying slightly in their shapes, are used to chip off unnecessary projections and to smooth surfaces. In working upon an ideal statue the artist, starting with his conception of the motive or idea of the work, is aided by models, and by the study of casts and busts.

PUTTING THE WORK IN PLASTER.

When the bust or statue is completed in clay it must be put into plaster, for the clay, drying rapidly on exposure to the air, shrinks in size and is liable to crack. With this the sculptor has little to do. The services of plaster modelers, usually Italians, are employed. The first cast, which is to form the mould of the permanent cast, is made in two parts like the halves of an oyster shell. There are two ways of doing this. Often a string is passed over the head of the bust, coming down over each ear. Then the liquid plaster is thrown on before and behind this string until the bust is completely covered. While the plaster is still soft the string, taken by each end, is lifted straight up and out, thus cutting a division between the two halves. After hardening the halves are chiseled away from the bust and then fitted together, forming a mould. Another method is to put on a narrow band of clay from the shoulders over the sides and top of the head of the bust. The plaster is then thrown against this band until the bust is entirely encased. The clay is thereupon removed, but enough adheres to the edges of the plaster to prevent them from sticking together. In either case, when the two halves are removed, their interior, giving, of course, an exact impression of the bust, is liberally anointed with soap and olive oil. This is to prevent the liquid plaster that is to be poured into the mould from adhering to the sides. When the halves are fitted and bound together the liquid plaster is poured in and allowed to harden. Then the shell, owing to the use of the oil, is readily chiseled away and the plaster cast is complete. In case of a large statue, the parts are usually separable, and arms, legs, the head, and trunk are cast in separate pieces. A similar process is carried out for decorative forms of sculpture like friezes, fire-places, and the finer forms of bass-reliefs that sometimes decorate ceilings.

After being cast in plaster the bust or statue is ready to assume its permanent form in marble or bronze. Marble cutters and bronze casters form two distinct classes, the former being usually Italians and the latter Frenchmen. In selecting a block of marble, of which the best comes from Italy, great care is taken to avoid yellow discolorations and flaws. After chiseling away the outer part of the block of marble, so that a rough likeness of a head is approached, the marble cutter is aided by a curious instrument which it is rather difficult to describe. It resembles somewhat a small wooden cross, the arm of which is movable, and has attached to it a finger which can be adjusted in any position. Three points are taken on the plaster bust, usually one on the forehead and one on each shoulder. These are marked by little metallic disks which are pasted on, or short tacks with broad heads are driven in. The cross is placed against the bust so that the extremities touch these three points, the exact spots where they come in contact with the cross being carefully noted. Then while the cross is in this position the adjustable finger is moved until it end touches a given point on the bust and it is secured in place. Then three points are taken on the marble corresponding to those on the plaster, and the cross is placed against them in exactly the same position. But the roughness of the marble prevents the movable finger from touching the fourth point as it did upon the plaster. Hence the workman carefully chisels and files away the marble until this finger can assume the same position in which it had been placed on the plaster, when it is evident that that point on the marble corresponds exactly to the similar point on the plaster. Then the cross is placed upon the plaster again, and the finger moved until another fourth point is marked by its adjustment. Removing the cross to the marble, inequalities are cut away until the finger is in place and a second point is secured. This process continues, aided by various measurements and a trained eye, until the plaster bust is reproduced almost exactly in marble.

DIFFICULTIES OF CASTING IN BRONZE.

The process of bronze casting is exceedingly complicated and difficult. Some sculptors send their work to France to be cast, and the bronze casters employed by artists in this city are almost all Frenchmen. Sand is the material used for moulds. Statues are usually cast in separate parts, but a brief description of the way of securing a bronze cast of a bust will indicate the method of the work. Taking sand, moistened often with lager beer, which renders it more sticky, the workmen put it upon the bust until a cake of the wet sand is in place, covering perhaps the chest. This dries in position, and then another piece is plastered on, enveloping the front of the neck, and so on until the whole of the bust is encased in pieces made of this wet sand, which dries and hardens in place. Over this first layer made up of several pieces is put an outer shell of sand. The whole mass is then put into a box open on two sides and secured from rolling about by long nails. Here it remains and dries for a time. Very carefully the outer shell and the inner layer are chiseled away from the bust in halves, the interior of which, when fitted together, gives, of course, an impression of the bust. The hollow mould formed by binding together these halves is filled with fine porous sand, moistened and prevented from adhering to the sides of the mould by the use of unguents. This hardens, then the halves of the mould are removed, and a cast is obtained of the bust in sand.

But the most difficult part of the work is to follow. If the bronze casting is to be a quarter of an inch in thickness,

a quarter of an inch is carefully filed away from the whole surface of this sand bust that there may be just that space between the bust and the sides of the mould when the melted bronze is poured in. Moreover, the sides of the mould must be kept at the same distance from the bust throughout to avoid touching at any point. The inner layer of the mould is in several pieces. Into these pieces short nails are carefully inserted, so that one end is buried in the inner surface of the mould while the other will pierce the sand bust and serve as a support. All over the interior of the mould these nails are inserted of exactly the proper length, so that when the halves of the mould are fitted together over the sand bust a space will be left between the mould and the bust of a quarter of an inch. When the bronze is poured in, these nails are melted and disappear.

In the last process, that of making the bronze cast, two precautions must be observed—one, that the air may escape freely; and the other, that the melted bronze may reach the different parts of the mould as nearly as possible at the same instant. Unless this is done the bronze hardens and the cast is imperfect. To secure the general and simultaneous introduction of the bronze, little canals are made in the sand, so that the bronze running down them strikes half a dozen parts of the bust at the same instant. Openings, or "gates," as they are technically called, are made for the escape of the air. After allowing the bronze time to cool and harden, the mould is knocked away and the bronze bust, which incloses, of course, the sand bust, is subjected to a keen examination, in order to detect flaws or defects. The whole process is necessarily exceedingly slow. Two weeks are required often to cast in bronze a single bust. The mechanical ingenuity, time, skill, and painstaking required, in addition to the skill of the sculptor, go to account for the expensiveness of works of art in marble and bronze.—*N. Y. Tribune.*

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PRACTICAL USES OF ELECTRICITY.

By PROF. CHARLES A. YOUNG, Princeton College.

THE introduction of electricity into the business of life is probably to be the most noteworthy feature in the history of economic civilization during the last half of the nineteenth century. The latter part of the eighteenth was characterized, speaking broadly, by the invention of the steam-engine, the substitution of machinery for hand-work, and the development of the factory system of manufacture; the first half of our own century, by the introduction of the railway and the steam-ship, and the commercial phenomena which necessarily resulted from such improvements in the means of transportation; similarly, unless all signs fail, the present half-century will hereafter be memorable as the period when man subdued to his service the mysterious power of electricity. It is true that before 1850 science had discovered nearly all the facts and principles upon which the present industrial applications of electricity depend. The galvanic battery, the magneto-electric machine, the telegraph, and the electroplating bath already existed, and the two latter were beginning to be used commercially. But at that time the world would hardly have felt the difference if by some strange accident it had suddenly lost the use and knowledge of them all. Thirty years have changed all that. Imagine that this morning every telegraph wire had disappeared, every galvanic battery had lost its virtue, every dynamo-machine was stopped—that all communication and operation by means of electricity had come to an end; how profoundly the whole community would be affected before nightfall! When a storm, a few months ago, prostrated many of the telegraph lines around New York City, business came almost to a standstill for the time. And while electricity is already so important a factor in our business life, it is impossible to doubt that by 1900 it will hold a far more dominant position. Every year, almost every day, brings to light some new application of this agent, and its use develops with continually increasing rapidity.

We propose in the present article to discuss the subject in a general and, so far as may be, untechnical manner, for the purpose of giving our readers an idea of the extent and variety of the existing applications of electricity to the arts of life, and the reasons for expecting their rapid multiplication in the near future. We do not aim at scientific completeness, and we shall not scruple to treat with disproportionate brevity those matters with which intelligent people are already familiar, in order to gain space for other topics at present less generally understood.

And first, by way of introduction, a few words as to the nature of electricity—a confession of ignorance. All that science can do at present is to define it as the unknown cause of certain effects which are observed when a piece of amber (*electron*) is rubbed—an observation dating back two thousand years. It is now known, of course, that not only those phenomena, but a whole multitude of others, depend upon the same cause. As to the real nature of the cause we have no certain light as yet; we cannot tell whether electricity is some peculiar kind of substance, or some modification or motion of ordinary matter. In the case of heat, which for a long time was thought to be a substance and called caloric, experiment has settled the question, and proved it to be merely a mode of motion. In reference to electricity no such decision has yet been reached. No phenomena have thus far been discovered which absolutely negative the notion that it may be a subtle, imponderable fluid or fluids, endowed with certain peculiar faculties of attraction and repulsion, and more or less freely circulating among the particles of bodies. According to this view an electrical charge consists in the collection of some abnormal quantity of this substance in the charged body; an electrical discharge is, then, the actual transference of a quantity of the fluid from one body to another, and an electric current is such a transfer continuously progressing.

Another view, however, seems to carry, at present, a greater weight of opinion in its favor—that, namely, of Maxwell. Accepting the idea of a medium filling all space (the luminiferous ether of optics), he regards an electric charge as the establishment of a peculiar state of strain among the atoms of the charged bodies, and in the medium between them. A discharge consists in the sudden relief of this strain by a giving way of the intervening medium, without necessarily implying any transfer of substance through it; and an electric current is a rapid succession of such discharges. In its application the theory is mathematically difficult, but it explains many facts which the fluid theories fail to touch, and opens the way for the establishment of relations between electricity and the other physical agents, especially light and heat. It is to be expected that the progress of science and mathematics will in due time furnish some *experimentum crucis* which will discriminate between the two hypotheses, or not impossibly upset them both. There is certainly great probability that some hypothesis will yet be found which will include in one general theory all the physical agents—light, heat, gravity, and chemical affinity, as well as electricity and magnetism. But the hour and the man have not yet come.

We have confessed ignorance as to the absolute nature of electricity; but the reader must not suppose, therefore, that there is any corresponding obscurity and uncertainty as to the phenomena it produces, and the laws which govern them. We may not know what electricity is, but we can measure it in "farads" and "webers" as accurately as water can be measured in "quarts" and "inches." We can express electrical pressure in "volts" as precisely as water-pressure in feet of "head;" and we can describe the resistance of an electrical conductor in "ohms" as definitely as the frictional resistance of a pipe of given size and length upon a stream of water flowing through it can be expressed. It is no more necessary to know the nature of electricity in order to deal with and utilize it, than it is to know the nature of water in order to make it drive our mills; although, of course, the more we learn about either the better we can manage it.

Unquestionably the most important of the practical uses of electricity hitherto developed is the communication of intelligence between distant points; not only in the telegraph proper, and the telephone, but in all the various signaling arrangements where electricity is made to serve as the nervous system of a complicated organization, co-ordinating the action of the different portions and bringing them under central control.

The history and operation of the telegraph is so familiar to all intelligent persons that we need not spend much time in its discussion. Though not yet forty years old, it has already become such an essential part of our civilization that its loss, as has been said, would instantly paralyze the life of the world. All the great operations of business depend upon its use. Our railways are run by its aid, and without the wire the carrying capacity of any important road would practically be reduced at least one half, because trains could no longer be moved at small intervals without constant danger of collision.

There may be a question whether there is really any advantage to mankind in the rapidity with which "news" now makes its way in the world; but there can be none that the fact is a most important, even a controlling, element is determining the differences between the characters of the men of the eighteenth and nineteenth centuries. The only reasonable expectation that our people, spread over so vast and various a country, will remain permanently one nation, hangs upon the hope that our modern means of communication will so intermingle us and our ideas that we shall measurably be freed from provincialism and sectional dissensions by becoming personally acquainted with each other, and having presented to us from day to day the same material for thought and feeling. Thus boundary-lines virtually contract and a continent becomes a country.

The magnitude and extent of the telegraphic system in the United States alone is something amazing. New York City itself has about 6,000 miles of telegraph wire, and there are nearly 300,000 miles in the whole country—enough to reach from the earth to the moon and a long distance beyond, since our satellite is only 240,000 miles away. Many of these, too, count for two or four apiece, being worked "duplex" or "quadruplex;" *i. e.*, in the language of the electrician, they have associated with each of them several "phantom" wires, which, having no actual existence, yet answer all the telegraphic conditions of metallic conductors. We know of nothing more ingenious or surprising than the methods (for they are various) by which a single wire is thus made to serve the purpose of many, in transmitting, without confusion or interference, several messages at once, some in one direction, and others in the opposite.

We have not before us the exact statistics of the subject, but the whole length of telegraph wire on the earth's surface and beneath its oceans cannot be far from a million and a quarter of miles. Five years ago it was reported at 978,000, and since then the erection of new lines has been going on faster than ever before.

And not only has the length of the lines been growing, but their efficiency also. We have spoken of the contrivances by which one wire is made to answer the purpose of three or four, but besides this the instruments and methods of telegraphy have been improving, so that a quadruplex wire of to-day, worked with some of the "rapid telegraph" apparatus, is capable of doing at least ten times as much business as one wire could have carried ten years ago.

How far the telegraphic system of the world will be extended in the future it is impossible to predict. Wherever civilization goes the wire will go, of course; and, so far as can be judged, in lands which now have the telegraph the lines will be greatly multiplied, though the competition of the telephone will necessarily be felt. It is quite within the range of possibility that, so far as epistolary correspondence is concerned, the mail-bag may some time be entirely superseded by the wire. Perhaps it is hardly likely, however, since the newspaper and other printed matter will always demand a postal system, and so long as that exists letters will probably continue to be written and sent.

We have alluded to the competition of the telephone. It is very difficult, however, to draw the line between the telegraph and telephone, and in England the government, which has bought out the private companies and works the telegraph lines as a part of its postal system, refuses to recognize the distinction. If there is a distinction to be maintained at all, it would probably lie in this: In telegraphing, the sender and receiver of the message employ a third person, and perhaps several persons, to transmit the message between them; the process is analogous to that of sending a package or letter by a conveyance. In telephoning proper, on the contrary, the sender and receiver converse directly, without the intervention of any one. The apparatus is virtually only a speaking-trumpet, and the operation is analogous to shouting across an interval of space. Of course in this view of the matter the peculiarity of the instrument itself drops out of sight. Should the telephone be so far improved that it will work easily over distances of hundreds of miles—as it probably will*—then it is likely to displace most of the present telegraph instruments at the minor stations, simply because it can be operated by any person, without requiring the peculiar skill now necessary to send and read a telegraphic message. In railway telegraphy especially its satisfactory introduction would be a great gain. For through business, however, it is probable that some form of rapid telegraph instrument, more or less analogous to those now in use, will be retained, because such instruments can be operated with multiplex wires, and are capable of transmitting in an hour many times the number of words which could be uttered by the most rapid speaker.

It is not easy to form an idea how much the direct use of the telephone is likely to extend. In our cities and large towns it must, of course, find its principal use, and it is very probable that the time will come when, as a matter of municipal organization, every house in every considerable city will have its telephonic connection with some central station. The number of purely private lines for purposes of business and friendship is sure also to be very great; it is already large, and would by this time have become vastly larger but for the heavy royalty. Five or ten dollars a year is more than most people are willing to pay for the mere use of an instrument which can be constructed for one or two dollars.

It is perhaps not impossible that some forms of the telephone may be used for other purposes than the mere transmission of conversation. Mr. Edison's "loud speaking" telephone is certainly a most extraordinary instrument; we shall never forget the sensation of hearing it for the first time. Several of us were listening intently, with telephones of the usual pattern, to the voice of the person who at the other end of the line was reading something to us from a newspaper. We could hear him well enough when everything was perfectly quiet, but it required close attention. Suddenly the little chalk cylinder of the new machine was put in motion, and at once the whole room was filled with the voice of the reader, as distinct as if he were in our midst, and much louder and more resonant; the tones were perfectly clear, but a little strange, just enough so to heighten the sensation. With an instrument of this kind a speaker of feeble voice could address an audience of any size, and at a distance of many miles, far more effectively than if he were before them, at least so far as the mere utterance of his ideas is concerned; and he could speak not only to one audience, but to several at the same time if the occasion demanded.

The use of electricity for the communication of various kinds of signals which can hardly be considered as telegraphic is very important and extensive. Take for instance our burglar-alarms, and the electric annunciators which in our hotels and steamboats have superseded the old system of bell-wires. In many kinds of textile machinery also, where it is important that the breaking of a thread or any derangement of the machine should at once arrest the movement, electricity is found to furnish the most prompt and reliable means for effecting the purpose. Fontaine mentions an instance where the application of such a device has reduced the necessary number of operatives from one for each knitting-frame to one for ten; four operatives aided by electricity taking the place of the forty previously needed.

In general, it may be said that wherever the nature of an organization or machine is such that something analogous to a nervous system is required to make it efficient, electricity supplies the want better than anything else, at least if the distances to be covered are at all considerable. The organist sits at his keyboard, and by the help of electricity manipulates pipes placed at any distance and in any position determined by the architect. The astronomer, without moving his eye from the instrument, communicates his observation to the chronograph by a tap of the finger, and secures a permanent record of the moment.

The clock of the observatory at Washington sends out its beats each noon over many thousand lines of telegraph wire, and drops the ball which furnishes our principal seaport with its standard time. Several other observations in this country do the same thing to a more or less limited extent, and in Great Britain the system is far more complete and thoroughly organized than here. The Greenwich signals go to almost every important city in the kingdom, and all the railroads are run by Greenwich time. In other parts of Europe, in Germany and France especially, the system is almost equally prevalent, and is gaining ground continually. In many cases it is not considered enough to send such time-signals once or twice a day merely. The beats of the standard clock of the Cambridge Observatory are transmitted continuously to some twenty different stations in Boston, and there is a similar time service in New York, which furnishes to the subscribers the beats of a standard clock. Many systems of electric clocks are also established in our railroad-stations and elsewhere, the clock face being controlled by the action of a distant timepiece moving its hands either continuously or at stated intervals. In Paris a similar system has been introduced on an extensive scale within the last few months, at the expense of the municipal authorities. The standard clock of the National Observatory is connected by special lines with about thirty "horary centers." At these points are placed clocks the pendulums of which are continuously controlled by impulses sent every second from the observatory, and they in their turn distribute their beats to numerous stations in the vicinity. The whole city is thus supplied with time uniform and correct to the second.

It would take us too far from our immediate purpose to discuss here the feasibility and advantages of a uniform time over the whole extent of our country—uniform, that is, as to its *minutes* and *seconds*, the hours being varied where necessary, so that the standard railroad and business time should nowhere differ more than half an hour from the true local time. There are some obvious objections, of course, but there is little doubt that they will ultimately be overruled in view of the importance of an authoritative standard, a necessity which will be felt more and more imperatively as the means of communication multiply and grow more swift. It is not unlikely that the system may even reach beyond the limits of a nation, so that all the English-speaking world at least will come to live by Greenwich time—by telegraph, of course, if at all.

It would be impossible, and it is not necessary, to enumerate all the different forms of signaling apparatus—fire-alarms, watchman-inspectors, and such—which depend upon the use of electricity for their efficiency. It is enough to say that contrivances of this kind are multitudinous, and many of them are of great importance and in extensive use already.

And as to future inventions we may lay down the fundamental principle that by means of electricity it is always possible for a person to effect at any distance any mechanical operation which he could perform if he were on the spot. It is a mere question of expense; the number of telegraph wires needed may be so great, and the cost of the apparatus so high, that the operation would not pay; but so far as possibilities are concerned the human arm is now virtually as long as the electric wire. I can sit in my study and steer a torpedo boat in New York harbor, or ring the bells of Boston, or play the organ in St. Peter's, or explode a mine in China, or write a letter on the desk of my correspondent in Constantinople. Just such things are done now every day, and will be done more frequently and easily hereafter.

* Since this was written it has been announced that Herz, in Germany, has made an improvement in the telephone, by means of which, without using batteries of any inordinate strength, he has been able to converse satisfactorily over circuits exceeding three hundred miles in length, and that, too, when part of the circuit was a submarine cable. We have not yet seen any authentic description of his invention.

We ought not to pass, with a bare allusion, the use of electricity in the management of explosives, for it has greatly increased their efficacy in military and mining operations. We all remember, of course, how, a few years ago, the touch of a little child's finger blew up the reef in Hell Gate. Any other known method of firing the mine would have deprived it of much of its power, because it would have been impossible to secure the simultaneity upon which the efficiency of the blast depended. At present nearly all the powerful explosives now in vogue are used only in connection with electric fuses of some kind or other. For safety, convenience, and certainty of action they are as immensely superior to their predecessors as are the new explosives themselves.

Electricity finds another extremely important practical application in a widely different range of uses—by means of its effect upon chemical reactions. As typical may be mentioned the electroplating industry, the electrotype, and the use of electricity in certain metallurgical and chemical operations.

We are not sufficiently familiar with the subject to be able to give statistics in respect to these matters, or even to enumerate all the different applications of electricity in this branch of technology Every one knows, however, that the business of electroplating alone is something enormous. The great firms of Elkington, in England; Christofle & Co., in France; and the Meriden and Providence companies, in this country, not to mention others nearly if not quite as important, employ operatives by the hundred and deposit silver and gold literally by the ton. In the magic bath the precious metal is torn off, atom by atom, from the shapeless lump, and transferred to the surface it is to clothe and beautify as if by invisible gnomes, working with inimitable speed, deftness, and docility.

The same agent is employed, and the same principles are involved in the processes by which wood-cuts and engravings are copied and the pages prepared for printing. The plate or block upon which the artist has expended his skill is not subjected to the wear and tear of the press, but facsimiles are made in any necessary number by means of the electrotype. These endure the rough service, while the original is kept in reserve ready to be recopied whenever wanted.

One curious application of the process is in the manufacture of the so-called compound telegraph wire, which consists of a central wire of steel covered with a coating of copper. This coating is deposited upon the steel by galvanic action, while the wire is drawn continuously through a long trough containing the necessary solution.

Electricity is used also in certain processes for the reduction of copper and other metals from their ores, and in the manufacture of certain chemicals extensively employed in the arts.

A few years ago the only generator of the electric current in ordinary use was the galvanic battery in some form or other. For all telegraphic purposes it answered very well, and fairly for the processes of electro-chemistry. But it was always a costly and troublesome affair when currents of any great strength were needed, and is now practically superseded in all such cases by mechanical generators, which depend for their efficiency upon the rapid motion of coils of wire in a magnetic field. The machines of twenty years ago were cumbrous and inefficient; but in 1866 Wilde, in England, constructed one involving several new principles and possessing a power before undreamed of; it is the type and original of many of the best machines now in use, although it has, in the development, received from Varley, Wheatstone, Siemens, and others numerous alterations and improvements which have greatly increased its efficiency. In 1871 Gramme, in France, introduced another machine of peculiar construction, which was at once recognized as superior to anything then known; and it still keeps its place, hardly surpassed by any even among the newest.

The machines best known in this country at present are those of Gramme, Siemens, Brush, Weston, Maxim, and Edison, though they have many rivals, some of them perhaps their equals. Any of those named, when driven under the conditions for which they were designed, are most effective converters of horse-power into electricity, the best of them having been shown by careful experiment to realize an efficiency of nearly 90 per cent; that is to say, if the electric current produced by the machine is made to heat a coil of wire immersed in water, it is found that the quantity of heat developed is 90 per cent of that which would be theoretically equivalent to the energy expended in driving the machine.

A word as to the expression "efficiency," so variously used as to have led to much ambiguity. As we have just employed it, the term denotes simply the ratio between the power expended in turning the machine and the useful effect produced. In this sense of the term that machine is most "efficient" which gives the greatest amount of electric work in return for each horse-power of propulsion without regard to the magnitude or expense of the machine itself. Sometimes, however, the matter is discussed with reference to the cost of the machine required to produce a given current, and in that case, though only loosely speaking, the most "efficient" machine is the one which is capable of giving the most powerful current for the money expended in building the apparatus, without regard to the expense of driving it. Again, since the strength of the current produced depends upon the arrangement and size of the wires through which it circulates, it has been inquired what arrangement of the circuit would enable us to get the greatest amount of electric work from a given machine; or, *vice versa* what machine will produce in a given circuit the maximum effect; and in this sense the most "efficient" machine is the one which will do the most work under the circumstances of the case, and that is the most "efficient" circuit which will realize the most work from a given machine; the expenditure of driving energy being lost sight of in this case also, as in the preceding.

Of course the most efficient machine in a commercial sense is the one which will give the greatest effect at the least *cost;* the cost being made up of two items—one, the expense of the driving power; the other, the interest on capital and the allowance for wear and replacement. In these days of low interest it will evidently pay to aim at durability and economy of power, even at a considerable first cost. Generally speaking, it may also be said that it is much cheaper to generate electricity in large quantities than in small. A machine which consumes directly the whole energy of a hundred horse power steam engine will produce its current for considerably less than it would cost to run twenty machines, each using five horse-power, provided always that profitable employment can be found for such a tremendous current; for it is possible to conceive of a Great-Eastern among dynamo machines - one too large to pay.

The ability to produce by means of such machines currents of any desired power, and at a reasonable expense, has opened for electricity an enormous range of uses which were out of the question in the days of galvanic batteries. It is quite within bounds to say that to produce the current which operates one of the electric-light circuits on Broadway by means of a battery would cost from ten to twenty times as much as it does to generate it in the present manner by means of a steam-engine; and not only would it cost more, but it would be quite impracticable, except by most extreme precautions, to keep the current running without interruption as much as twenty-four hours at a time.

It need hardly be said here—for every one's thoughts are more or less full of the matter at present—that already one of the most important applications of electricity is to the production of light. So far as regards the illumination of large spaces by lights of high intensity the problem may be considered as solved by a number of inventors whose different systems are already in successful operation. As to the lighting of houses and limited areas more perhaps remains to be done; but even as things stand to-day it is beyond question that the thing is entirely feasible, and at a cost considerably lower than that of gas.

The lights employed are of two kinds—the "arc" lights so called, which are produced by a current of electricity playing between two slightly separated pencils of carbon, and the "incandescent" lights, which are produced by a current passing through a continuous filament or slender rod of some refractory substance, which is also usually carbon. There are other possible forms of the electric light, but none of them appear likely to find much use in competition with the two we have named, though in some cases the light produced by passing a rapid succession of discharges from an induction coil through a tube filled with gas at a low pressure is utilized for scientific purposes.

The "arc" light dates back to the experiments of Davy in 1813, who first produced it by touching together two pieces of charcoal attached to the poles of his historic battery. On one occasion he employed a battery of two thousand pairs of plates (probably equivalent to about a thousand of those now used), and produced an arc nearly five inches in length; *i. e.*, the current continued to pass even after the charcoal pencils were separated by that space. It is very seldom even now that such effects are exceeded. The experiment remained, however, a rare and costly one for thirty years. About 1844 Foucault, in Paris, hit upon the happy idea of substituting for the pencils of willow charcoal, used up to that time, rods of the dense hard carbon cut from the deposits which line the insides of old gas retorts. These new carbons last much longer, and are more manageable. This improvement, the introduction of the powerful batteries of Grove and Bunsen, and the invention of effective lamps or regulators, soon made the use of the electric arc much more common than before, though still sufficiently rare.

In 1858 an electric lamp was established at the South Foreland light-house, on the English Channel, driven, not by a battery, but by a machine constructed by Holmes; a machine presenting no new features of importance, but simply a magnification of the smaller machines then found in every cabinet of physical apparatus. In 1863 a similar light, driven by a machine of slightly different construction, was established on the French side at La Hève. These lights have been running ever since, and several others have been added at different points upon the coasts of France and England. The machine invented by Wilde in 1866 (already spoken of) quite changed the aspect of affairs, and since then progress has been rapid and continuous.

At present the carbon rods employed are usually manufactured for the purpose by some one of many different processes of alternate compression and baking. They are rather expensive, so that their cost, according to the estimates of Fontaine and others, generally exceeds by a considerable amount that of the fuel burned in the engine which drives the current-generator. They are usually burned in "lamps" so constructed as to regulate for themselves the distance between the points; in some of them a new pair of carbons is automatically substituted for one that has been consumed, and in nearly all an arrangement is provided by which, in case of the failure of the lamp for any reason, the circuit will be closed so as not to affect other lamps which may be connected with the delinquent.

The number of these different electric lamps is already very great, and is continually increasing. Every bulletin of the patent-offices is sure to contain several inventions of this kind, some of them comically worthless, but many of them exceedingly ingenious and well thought out. Between the better lamps there is not much to choose, the steadiness and general good behavior of the light depending mainly on the excellence of the carbons and the uniform action of the generator.

At present "arc" lights are run both by continuous and by alternating currents; *i. e.*, in some cases the current is steadily in the same direction, while in others the current consists of pulses alternate positive and negative, succeeding each other at the rate of from 10 to 100 per second.

In a lamp actuated by a continuous current the positive carbon, for reasons as yet undiscovered, becomes much hotter than the negative, and is consumed about twice as rapidly. This requires a special mechanism for keeping the light at the same point, and demands attention to make certain that the wires are properly connected to the two terminals of the lamp. Where alternate currents are used this difficulty is, of course, obviated; the lamp becomes simpler, and it is entirely different in what order its terminals are connected with the circuit. Nor is the generator any more difficult to construct, though probably it is slightly less economical of power.

There is, however, one literally fatal objection to the use of alternating currents which ought to prohibit their use. The wires from a continuous-current machine can be handled without danger to life; the shock obtained, though disagreeable enough, is not fatal. With the alternating current it is different; the shattering power of the intermittent shocks is tremendous, and several persons have already been killed by accidents from them. Probably all recollect the recent case upon the Livadia.

The amount of light which can be produced by an "arc" lamp is enormous, depending of course, upon the size and excellency of the carbons and the power of the current; and the larger the light the more economical it is; *i. e.*, a great light costs less for each candle-power than a small one. With the small lamps it is usual to get from 500 to 1,200 candles* for each horse-power consumed by the engine; large burners do better, running as high as 2,000 or 2,500. Probably the most powerful lamp ever yet constructed is one recently made and tested in Cleveland by the Brush Electric Light Company under a special order from the British Admiralty. It is estimated at 100,000 candle-power, using carbons two inches and a half in diameter, and consuming forty horse-power. The ordinary arc-lights, of which there are now so many in our different cities, consume from one and a half to two horse-power, and give lights varying from 800 to 2,5 0 candles.

For a long time it was found very difficult to run more than one or two lamps in a single circuit, and machines were constructed which supplied each lamp with its own separate current through its own conductors. Of course this added greatly to the expense, especially in the matter of conductors. The difficulty has, however, been overcome in great measure, and at present Mr. Brush, with some of his more powerful machines, drives as many as forty lamps in one circuit, the remoter ones being as far as five miles from the engine, and that without any inordinate expense for the conducting cable.

As to the economy of the system, there can be no question that even in rather unfavorable situations, as, for instance, in the lighting of streets where the lamps are pretty widely separated, the electric light is at least as cheap as gas at one dollar a thousand feet. Under the most favorable circumstances, as in the lighting of mills and factories, where no separate plant is required to furnish the driving power, the saving is very great.

The total number of such lamps already in use is enormous. The Brush Company alone reported last January more than 6,000 in operation—1,200 of them in foreign countries. In this country 4,860 were distributed, as follows:

800	lamps in	metal-working establishments.
1,240	"	cotton and woolen mills.
425	"	stores, hotels, churches, etc
250	"	parks, gardens, docks, etc.
277	"	railway-stations.
1,500	"	streets of cities.
380	"	unclassified.

Probably the lamps of Siemens and the so-called candles of Jablochkoff are still more numerous in Europe, while those of other systems are not greatly behind.

Lights of this kind, however, are not suited for all purposes, as, for instance, for household illumination. What is wanted here is a lamp which will furnish somewhat more light than an ordinary gas-burner and will require no skilled attention to maintain it. To compete with gas it must be at least as cheap, and must not subject the user to any greater inconveniences.

What are called incandescent lamps best answer these conditions. When a current is passed through a conductor it heats it more or less and if the conductor is of such a nature as to oppose considerable resistance, its temperature may rise far above the incandescent point, so that it will become luminous and shine, *without consuming*, as long as the current passes. At first it was attempted to use metal filaments, but it was soon found that the temperature required to make them give off much light is perilously near that of fusion, even with the most refractory. Slender rods of carbon were then tried, and so far as principles are concerned, the lamp invented by Starr and King in 1845 embodies pretty much everything of value in the newest. They employed carbon and inclosed it in the most perfect vacuum then known to science, in order to prevent the wasting action of the air. But at that time rods of carbon could not be made sufficiently slender and compact, nor were the present means of producing a perfect vacuum available, and, above all, the dynamo-electric machine existed then only in embryo. It would take us beyond our reasonable limits to trace the history of lamps of this class (though that of Lodyguine, invented in 1873, must not be passed unmentioned), but we have at present one which seems likely to meet all the requirements of the problem. We say *one*, because the finished thing is essentially the same as made by either of the three different inventors who claim it—Swan in England, and Edison and Maxim in this country. There are, however, more or less important practical differences in the methods by which the carbon filament, which is the essential feature and light-producing agent in all of their lamps, is prepared and connected to the conductors, as well as in the operations by which the glass vessel inclosing the filament is exhausted and sealed.

Of course this is not the place to discuss the questions of priority and patent rights involved in their respective claims.

These lamps use up nothing, in shining, except the current which excites them; they possess no complicated mechanism to be kept in order; they are small—not larger than an ordinary lamp-chimney; and they cost very little to construct in a large way, certainly not half a dollar apiece. On the other hand, they do not rival the arc-lights in brilliance (at least as a general thing, for Maxim has constructed a few of several hundred candle-power), and their luminous duty, if we may coin the expression, is as yet only between one and two hundred candles per horse-power, or about one sixth that of the arc-lights. The arc light is not, however, anything like six times as cheap as the other per candle-power, because its consumption of carbon pencils, as has already been said, costs more than the engine-power itself, while the incandescent light escapes this charge. Still the incandescent lamp cannot be regarded as absolutely imperishable, and as a matter of fact is seldom so perfect in all particulars as to last in practice more than two or three months; but the cost of replacement is trifling.

Besides these forms of the incandescent lamp there are others which, like that of Sawyer, more resemble the original lamp of the Starr-King patent. Instead of a slender carbon filament with an electric resistance of from fifty to two hundred ohms, they employ a small pencil of carbon some half an inch long, and about one-twentieth of an inch in diameter, inclosed in a case which can be taken to pieces to replace the pencil when consumed. The resistance of these lamps is generally only from five to ten ohms, so that they are used, several of them consecutively in the same circuit, like arc-lamps. The lamps of the Edison type, on the other hand, have resistances ranging from fifty to two hundred ohms, and are inserted into the circuit side by side (technically "in multiple arc"); the portion of the current which flows through one lamp passes through no other.

There are also lamps, like that of Werdermann, which are intermediate between the purely incandescent and the arc. The thin pencil of carbon from which the light emanates touches lightly a larger block of carbon, and produces at the point of contact a brilliant star of light, without, however, forming an actual arc. But the carbon pencil wastes away pretty rapidly, and on the whole the apparatus is probably inferior to either of the two between which it is a cross.

We shall not undertake to discuss at length the economical question as to the lighting of houses by electricity. As

* The unit of illumination ordinarily used in this country for photometric purposes is the light given by a sperm-candle of such size that six weigh a pound, and burning 120 grains an hour. An ordinary gas-burner is from twelve to fifteen times as bright.

against gas, advantages and disadvantages are both obvious: on the one side, a whiter light, freedom from heat and vitiation of the air, from foul smells and tarnish; on the other, the inability to store the supply against the time of need, the rather greater liability to interruption by accident, and the difficulty of graduating the brightness of a given lamp in an economical manner. One can turn down a gas-flame and burn it low. No effective arrangement is yet known for doing the same thing with an electric lamp, at least in a satisfactory and easy manner.

As to comparative expense it is yet too early to decide with much confidence. The necessary conductors and current meters on the electric system will probably about offset the service of gas-pipes and gas-meters, but they may turn out more costly than has been anticipated. The actual expense of producing the light, apart from all questions of interest on plant, will certainly be in favor of electricity.

But here another consideration comes up of great importance. The electric plant once being established and electricity "laid on" in the streets of a city as gas is now, it may be used very profitably for other purposes than that of lighting, especially for the transmission of power. The electric plant may thus be made to earn revenue by day as well as by night. Unless we are much mistaken, electricity will be more used in the near future as a means of transmitting power than for any other purpose.

Many attempts were made in the early days of electromagnetism to construct electro-magnetic engines; *i. e.*, to drive machinery by means of a galvanic current. There was no difficulty in making the machines go, but there was difficulty in making them pay. The simple fact is this: at current prices of mining, manufacture and materials, every horse power of energy developed in the current of a galvanic battery costs more than twenty times as much as a horse power generated by a good steam-engine, and no ingenious contrivances for using the current can evade the fundamental difficulty. To put it differently: the mere coal consumed in extracting a ton of zinc from its ore would produce as much power in the boiler of a steam-engine as could be got from the use of the zinc itself in a galvanic battery.

If, however, a method is ever found by which electricity can be developed directly, economically, and manageably by the consumption of fuel, without the intervention of steam or other engines, the case will be altered. To a certain extent the thermo-electric battery now does this very thing, but very imperfectly and wastefully.

For the present, then, we cannot profitably use battery currents to produce power; but we may use currents developed by a mechanical generator of electricity as a means of transferring power from one point to another; and apparently this is a far more economical method than any known system of mechanical transmission by wire ropes, water pipes, or compressed air. All that is needed is a suitable conductor from the electric generator to the electric motor, which is in construction identical with the generator itself, either being capable of driving the other. The conductor once laid remains without wear and tear, costing nothing but the interest. It would take us too far to discuss the conditions for the most profitable use of electricity in this way. We may say in general that currents of small quantity but high electro-motive force (like water streams of small velocity and high pressure in hydraulic pipes) are theoretically most economical; but then such currents are harder to manage on account of difficulties of insulation, so that a compromise must be effected. In practice it is found that many of the machines in use will transmit from one to ten horse-power a distance of a mile with a loss of less than twenty per cent.

One of the earliest applications of this principle was in some experiments by MM. Chrétien and Félix in France, in 1878. They plowed fields by electricity, substituting for the engine which had been used to pull the gang of plows a Gramme machine. They also used the same sort of machine upon a crane employed for the unloading of boats in the harbor of Sermaize, at an estimated economy over steam of nearly thirty per cent, after several months of trial.

In the electric railways of Siemens and of Edison the rails are used as the conductors, and the locomotive is replaced by a car on which is an electric motor deriving its current from the rails. By this arrangement it is possible to concentrate the motive power at central stations, and to substitute for the wasteful locomotives engines of a much more economical type. It is probable that for city tramways, elevated railroads, and other roads of similar description, the system will come into extensive use.

We have seen recent accounts of various machines driven by electricity. One is a pile-driver, in which the steam-engine is replaced by an electric motor. Another is an electric elevator, in which an electric motor carried in the car is driven by a cable brought to it from the basement, and by means of an endless screw work the gearing which carries the car up or down. This contrivance is absolutely safe; in case of the failure of the current for any reason the car does not fall, but simply stops, and can be worked up or down by hand from the inside so as to release its inmates. Another ingenious machine is an electric hammer by Siemens, designed to replace the steam-hammer for not too heavy work. All of these appear to be entirely successful.

Indeed, as Prof. Ayrton has pointed out, it seems very possible, perhaps even probable, that our whole industrial system is to be profoundly modified by this new possibility of economically transmitting the energy generated in large quantities and under the most favorable conditions, and so distributing it that it can be utilized a little at a time wherever needed. Instead of bringing operatives to their work and herding them in mills and factories, it may be possible to send the work to their homes and thus to avoid many of the most serious evils of our present methods.

Our limits forbid more than a mere mention of certain other uses of the electric current. Siemens has experimented upon the effect of powerful electric lights upon the growth of plants, and has clearly shown the possibility of forcing vegetation and fruitage in this manner to an almost unlimited extent. The same gentleman and Jamin, in France, have shown how to employ the electric arc in blowpipe and crucible so as to produce for industrial purposes intensities of temperature never before attained, and others have proposed to use the current as a means of ordinary heating and cooking in the household. As to this latter proposition it is enough, however, to say that the method cannot be economical, though it may be convenient in some cases. The steam-engine which produces the current never utilizes quite twenty per cent. of the heat produced by the combustion of its fuel, to say nothing of the subsequent loss in transmission.

Of the uses of electricity in medicine and surgery, we add nothing here, nor of its applications in strictly scientific research, these subjects lying one side of our purpose.

We must not close without an allusion to the International Exhibition of Electricity which is to be opened at Paris, next autumn, under government auspices. It is sure to be one of the most interesting and important exhibitions ever held. One will be able to see in action nearly every form of electric generator, all sorts of electric lights and motors, all kinds of telegraphic and telephonic apparatus, all the different appliances by which electricity is used in chemical and metallurgic operations, and the instruments for measuring and determining all kinds of electrical constants.

It will gather together the most magical and incredible of facts, some things completed, the beginnings of more, the seeds and embryos of almost a new civilization.

ILLUMINATING A FISH BY ELECTRICITY.

AT a recent soirée given at the Paris Observatory, Mr. G. Trouvé exhibited a few interesting electrical apparatus before a large audience, some of them being not only novel, but also quite curious. Among these may be mentioned the experiment of making a fish luminous. The object of the experiment was to demonstrate the importance of the electric polyscope from a surgical point of view. The polyscope, which we described and figured about two years ago, is composed of a series of reflectors, in the focus of which a platinum wire is brought to a white heat by means of a Planté pile. These reflectors are made in various forms. One of them may be placed in the mouth, and when the current is made to pass, the whole buccal cavity is illuminated to such a point that the teeth become translucent and show the state of their interior. One of these reflectors, placed at the extremity of an œsophageal sound, serves for lighting up the stomach and making it transparent. The apparatus are varied so as to adapt them to all the needs of the surgeon, physician, and dentist. In this mode of lighting, the production of heat is diminished as much as possible by the use of a very constant electric current, and very fine platinum wires coated with iridium. The heat radiated is very insignificant. But, to come to the experiment: M. Trouvé thrust down the throat of a living fish, swimming in an aquarium, a microscopic reflector connected by conducting wires with a handle which he held in his hand. The lights were then put out, and, as soon as the reflector was lighted by the action of the current, the entire body of the fish became so luminous and transparent that its vertebræ could be counted and all the details of its organism examined.

A LIVING FISH MADE LUMINOUS AND TRANSPARENT BY MEANS OF THE ELECTRIC POLYSCOPE

The importance of electrical apparatus of this kind for exploring the inner cavities of the animal organism results from the fact that the light, radiating little of heat, can be brought in close vicinity to the part to be examined. The polyscope has, therefore, come into extensive use, being employed in the hospitals of Paris, by surgeons in private practice, by dentists, and by veterinary surgeons, etc. In addition to medicine and surgery, it may be applied to other uses. Captain Mauseron, of Saint Thomas d'Aquin, for example, has employed it for examining the interior of bombshells and cannons. It may be also used without danger for lighting the interior of powder-mills, the reflector in such a case being inclosed within a triple envelope of glass.

TELEGRAPHIC TRANSMISSION OF PICTURES.

AT a recent meeting of the London Physical Society, Mr. Shelford Bidwell explained a method he had devised of transmitting pictures—or, rather shadows—by electricity.

The positive pole of a battery is connected through a set of resistance-coils to a piece of platinum wire, and the negative pole to a plate of zinc, upon which is placed a sheet of paper moistened with a solution of potassium iodide. The negative pole of a second battery is connected through a selenium cell with the same platinum wire, and the positive pole to the zinc plate. The point of the platinum wire is pressed upon the paper, and the selenium being exposed to a strong light, the variable resistance is so adjusted that the currents from the two batteries which pass through the paper in opposite directions exactly neutralize each other. The platinum point will now make no mark when drawn over the paper; but if the selenium is shaded, its resistance is immediately increased; the current from the first battery then predominates, and the path of the platinum point across the paper is marked by a brown line due to the liberation of iodine. The line is fainter the feebler the light is. This arrangement has been applied by Mr. Bidwell in his "telephotograph," exhibited to the meeting. The transmitter consists of a brass cylinder mounted on a screw spindle which carries the cylinder laterally 1-64th of an inch at each revolution. A pin-hole in the middle of the cylinder allows light to fall upon a selenium cell placed behind it within the hollow cylinder. The cell is connected in circuit with a battery and the line. The receiver consists of a similar metal cylinder mounted so as to rotate synchronously with the first, and having a platinum point pressing upon a sheet of chemical paper wrapped round the cylinder. This receiver and transmitter are connected up as described above with two batteries and a set of resistance coils.

The image to be transmitted is focused upon the cylinder of the transmitter and the resistance adjusted, and the receiving cylinder covered with sensitized paper. The two cylinders are caused to rotate synchronously, the pin-hole in the course of its spiral path covering successively every point of the focused picture. The amount of light falling upon the selenium will be proportional to the illumination of that particular spot of the projected image which is for the time being occupied by the pin-hole, and the intensity of the line traced by the platinum point in the receiver will vary in the same proportion. These variations will produce a picture which, if the instrument were perfect, would be a counterpart of that projected upon the transmitter. Simple designs cut out of tin foil and projected by a lantern have been successfully transmitted. With selenium and paper of greater sensitiveness more perfect results might undoubtedly be obtained. Professors Ayrton and Perry showed an experiment illustrating their plan for sending light and shade images by electricity. A selenium cell was connected in circuit with a battery and a coil of wire surrounding a tube along which a beam of light passed. A shutter having a small magnet attached was suspended in the tube like a galvanometer mirror, so that when a current traversed the coils, the shutter was deflected so as to close or partially close the tube and shut off the beam of light. It will be understood that when a ray of light fell on the cell and diminished its resistance, the current in the coils would increase to a degree proportional to the intensity of the ray, and thus the shutter would proportionally cut off the light in the receiver. If now a number of these elementary circuits were combined so as to provide a mosaic of cells to transmit the reflected image of an object, and a screen to receive the corresponding beams of light controlled by the shutters at the other end of the line, there would be a means of sending light and shade images by wire.

THERE was a very interesting conversazione of telegraph engineers held in London on April 11. Among the exhibits was a hitherto unpublished letter (in the possession of Mr. Latimer Clark), written in London on Dec. 15, 1716, by Sir Isaac Newton, and addressed to Dr. Law, who resided in Suffolk. The remarkable thing about this letter is that Newton seems to have anticipated Franklin's great discovery. The passage touching upon this point is as follows: "I have been much amused by ye singular phenomena [the word phenomena is written in Greek characters] resulting from bringing of a needle into contact with a piece of amber or resin fricated on silke clothe—ye flame putteth me in mind of sheet lightning on a small (how very small) scale. But I shall in my epistles abjure Philosophy whereof when I come down to Sakly I'll give you enow."

ON SO-CALLED RUSTY GOLD.

IN a recent lecture, Prof. Egleston gave some interesting data with regard to the causes which prevent gold from being amalgamated. After noticing that certain chemicals, such as sulphide of ammonium and sulphuric acid, form a film which prevents the gold from being attacked by mercury, he stated that perfectly clean gold, if hammered on an anvil, was brought into a state in which it could not be amalgamated. From this the professor argued that in order to reduce the losses in gold mills, the use of stamp mills, or other crushing machinery acting by impact, will have to be abandoned, and the stamp-batteries replaced by other forms of comminuting apparatus.

LOSSES IN THE PLATTNER CHLORINATION PROCESS.

In connection with the above paper, Prof. Egleston called attention to the precipitation of metallic gold by organic matter as a source of loss of the chlorination process; the gold being precipitated by the organic matter in the residues and thrown away.

THE HERRING.*

IT is now nineteen years since my attention was first specially directed to the natural history of the herring, and to the many important economical and legal questions connected with the herring fisheries. As a member of two successive Royal Commissions, it fell to my lot to take part in inquiries held at every important fishing station in the United Kingdom between the years 1862 and 1865, and to hear all that practical fishermen had to tell about the matter; while I had free access to the official records of the Fishery Boards. Nor did I neglect such opportunities as presented themselves of studying the fish itself, and of determining the scientific value of the terms by which, in the language of fishermen, the various conditions of the herring are distinguished.

Diligent sifting of the body of evidence thus collected and passed under review led to the satisfactory clearing away in my own mind of some of the obscurities which, at that time, surrounded the natural history of the fish. But many problems remained, the solution of which was not practicable by investigations which, after all, were only incidents in the course of a large inquiry, embracing a vast number of topics beside herrings and herring fisheries; and it is only within the last few years that the labors of the German West Baltic Fishery Commission have made such large additions to the state of our knowledge in 1865, that the history of the herring is brought within measurable distance of completeness.

Considering the vast importance of the herring fisheries of the Eastern Counties, it occurred to me when the President of the National Fishery Exhibition did me the honor to ask me to address you, that nothing could be more likely to interest my audience than a summary statement of what is now really known about a fish which, from a fisherman's point of view, is probably the chief of fishes.

I am aware that I may lay myself open to the application of the proverb about carrying coals to Newcastle, if I commence my observations with a description of the most important distinctive characters of a fish which is so familiar to the majority of my hearers. And perhaps it is as well that I should at once express my belief that most of you are as little likely to mistake a herring for anything else as I am. Nay, I will go further. I have reason to believe that any herring merchant, in a large way of business, who may be here, knows these fish so much better than I do, that he is able to discriminate a Yarmouth herring from a Scotch herring and both from a Norway herring; a feat which I could not undertake to perform. But then it is possible that I may know some things that he does not. He is very unlike other fishermen and fish-merchants with whom I have met, if he has any but the vaguest notions of the way of life of the fish; or if he has heard anything about those singularities of its organization which perplex biologists; or if he can say exactly how and why he knows that a herring is not a sprat, a shad, or a pilchard. And all kinds of real knowledge and insight into the facts of nature do so bear upon one another and turn out in strange ways practically helpful, that I propose to pour out my scientific budget, in the hope that something more may come of it than the gratification of intelligent curiosity.

If any one wants to exemplify the meaning of the word "fish" he cannot choose a better animal than a herring. The body, tapering to each end, is covered with thin, flexible scales, which are very easily rubbed off. The taper head, with its underhung jaw, is smooth and scaleless on the top; the large eye is partly covered by two folds of transparent skin, like eyelids—only immovable and with the slit between them vertical instead of horizontal; the cleft behind the gill cover is very wide and, when the cover is raised, the large red gills which lie beneath it are freely exposed. The rounded back bears the single moderately long dorsal fin about its middle. The tail fin is deeply cleft and on careful inspection small-scale are seen to be continued from the body, on to both its upper and its lower lobes, but there is no longitudinal scaly fold on either of these. The belly comes to an edge, covered with a series of sharply-keeled bony shields between the throat and the vent; and behind the last is the anal fin, which is of the same length as the dorsal fin. There is a pair of fore-limbs, or pectoral fins, just behind the head; and a pair of hind-limbs, or ventral fins, are situated beneath the dorsal fin, a little behind a vertical line drawn from its front edge, and a long way in front of the vent. These fins have bony supports or rays, all of which are soft and jointed.

Like most fishes the herring is propelled chiefly by the sculling action of the tail-fin, the rest serving chiefly to preserve the balance of the body, and to keep it from turning over, as it would do if left to itself, the back being the heaviest part of the fish.

The mouth of the herring is not very large, the gape extending back only to beneath the middle of the eye, and the teeth on the upper and lower jaws are so small as to be hardly visible. Moreover, when a live herring opens its mouth, or when the lower jaw of a dead herring is depressed artificially, the upper jaw, instead of remaining fixed and stationary, travels downward and forward in such a manner as to guard the sides of the gape. This movement is the result of a curious mechanical arrangement by which the lower jaw pulls upon the upper, and I suspect that it is useful in guarding the sides of the gape when the fish gulps the small living prey upon which it feeds.

The only conspicuous teeth, and they are very small, are disposed in an elongated patch upon the tongue, and in another such patch, opposite to these, on the fore part of the roof of the mouth. The latter are attached to a bone called the vomer, and are hence termed vomerine teeth. But, if the mouth of a herring is opened widely, there will be seen, on each side, a great number of fine, long, bristle-like processes, the pointed ends of which project forward. These are what are termed the gill rakers, inasmuch as they are fixed, like the teeth of a rake, to the inner sides of those arches of bone on the outer sides of which the gills are fixed. The sides of the throat of a herring, in fact, are as it were cut by four deep and wide clefts, which are separated by these gill arches, and the water which the fish constantly gulps in by the mouth flows through these clefts, over the gills and out beneath the gill covers, aerating the blood, and thus effecting respiration, as it goes. But since it would be highly inconvenient, and indeed injurious, were the food to slip out in the same way, these gill rakers play the part of a fine sieve, which lets the water strain off, while it keeps the food in. The gill rakers of the front arches are much longer than those of the hinder arches, and as each is stiffened by a thread of bone developed in its interior, while at the same time, its sides are beset with fine sharp teeth, like thorns on a brier, I suspect that they play some part in crushing the life out of the small animals on which the herrings prey.

Between these arches there is, in the middle line, an opening which leads to the gullet. This passes back into a curious conical sac which is commonly termed the stomach, but which has more the character of a crop. Coming off from the under side of the sac and communicating with it, by a narrow opening, there is an elongated tubular organ, the walls of which are so thick and muscular that it might almost be compared to a gizzard. It is directed forwards, and opens by a narrow prominent aperture into the intestine, which runs straight back to the vent. Attached to the commencement of the intestine there is a score or more of larger and shorter tubular organs which are called the pyloric cæca. These open into the intestine, and their apertures may be seen on one side of it, occupying an oval space, in the middle of which they are arranged three in a row.

The chief food of the herring consists of minute crustacea, some of them allied to the shrimps and prawns, but the majority belonging to the same division as the common *Cyclops* of our fresh waters. These tenant many parts of the ocean in such prodigious masses that the water is discolored by them for miles together, and every sweep of a fine net brings up its tens of thousands.

Everybody must have noticed the silvery air-bladder of the herring, which lies immediately under the backbone, and stretches from close to the head to very near the vent, being wide in the middle and tapering off to each end. In its natural state, it is distended with air; and if it is pricked, the elastic wall shrinks and drives the air out, as if it were an India-rubber ball. When the connections of this air-bladder are fully explored it turns out to be one of the most curious parts of the organization of the whole animal.

In the first place, the pointed end of the sac or crop into which the gullet is continued runs back into a very slender duct which turns upward and eventually opens into the middle of the air-bladder. The canal of this duct is so very small and irregularly twisted, that, even if the air-bladder is squeezed, the air does not escape into the sac. But, if air is forced into the sac by means of a blowpipe, the air passes without much difficulty the other way, and the air-bladder becomes fully distended. When the pressure is removed, however, the air-bladder diminishes in size to a certain extent, showing that the air escapes somewhere. And if the blowing up of the air bladder is performed while the fish is under water, a fine stream of air-bubbles may be seen to escape close to the vent. Careful anatomical investigation, in fact, shows that the air-bladder does not really end at the point where its silvery coat finishes, but that a delicate tube is continued thence to the left side of the vent, and there ends by an opening of its own.

Now the air-bladder of all fishes is, to begin with, an outgrowth from the front part of the alimentary canal, and there are a great many fishes in which, as in the herring, it remains throughout life in permanent communication with the gullet. But it is rare to find the duct so far back as in the herring; and, at present, I am not aware that the air-bladder opens externally in any fishes except the herring and a few of its allies.

There is a general agreement among fishermen that herrings sometimes make a squeaking noise when they are freshly taken out of the water. I have never heard this sound myself, but there is so much concurrent testimony to the fact that I do not doubt it; and it occurs to me that it may be produced when the herrings are quickly brought up from some depth by means of this arrangement. For under these circumstances the air, which the air-bladder contains, expands to such a degree, on being relieved from the pressure of the water, that deep-sea fishes with a closed air-bladder which are brought to the surface rapidly are sometimes fairly turned inside out by the immense distension, or even bursting, of the air-bladder. If the same thing should happen to the herring the like misfortune would not befall it, for the air would be forced out of the opening in question, and might readily enough produce the squeak which is reported. The common Loach* is said to produce a piping sound by expelling the air which this fish takes into its intestine for respiratory purposes.

At the opposite end of the air-bladder there is an even more curious arrangement. The silvery coat of the air-bladder ends in front just behind the head. But the air-bladder itself does not terminate here. Two very fine canals, each of which is not more than two-hundredths of an inch in diameter, though it is surrounded by a relatively thick wall of cartilage, pass forward, one on each side, from the air-bladder to the back of the skull. The canals enter the walls of the skull and then each divides into two branches. Finally, each of these two dilates into a bag which lies in a spheroidal chamber of corresponding size and form; and, in consequence of the air which they contain, these bags may be seen readily enough shining through the side walls of the skull, the bone of which has a peculiar structure where it surrounds them. Now these two bags, which constitute the termination of the air-bladder on each side, are in close relation with the organ of hearing. Indeed, a process of that organ projects into the front chamber on each side, and is separated by only a very delicate partition from the terminal sac of the air-bladder. Any vibrations of the air in these sacs, or any change in the pressure of the air in them, must thus tell upon the hearing apparatus.

There is no doubt about the existence of these structures which, together with the posterior opening of the air-bladder, were most accurately described, more than sixty years ago, by the eminent anatomist Weber, but I am afraid we are not much wiser regarding their meaning than we were when they were first made known. In fishes in general, there can be little doubt that the chief use of the air-bladder is to diminish the specific gravity of the fish, and, by rendering its body of nearly the same weight as so much water, to render the business of swimming easier. In those fishes in which the passage of communication between the air-bladder and the alimentary canal is closed, the air is no doubt secreted into the air-bladder by its vessels, which are often very abundant. In the herring, the vessels of the air-bladder are very scanty; and it seems probable that the air is swallowed and forced into the air-bladder just as the loach swallows air and drives it into its intestine. And, as I have already suggested, it may be that the narrow posterior canal which leads from the air-bladder to the exterior is a sort of safety-valve allowing the air to escape, when the fish, rapidly ascending or descending, alters the pressure of the water upon the contained air.

This hypothesis may be put forward with some show of probability, but I really find it difficult to suggest anything with respect to the physiological meaning of the connection between the air-bladder and the ear. Nevertheless such an elaborate apparatus must have some physiological importance; and this conclusion is strengthened by the well-known fact that there are a great many fishes in which the air-bladder and the ear become connected in one way or another. In the carp tribe, for example, the front end of the air-bladder is connected by a series of little bones with the organ of hearing, which is, as it were, prolonged backward to meet these bones in the hinder end of the skull. But here, the air-bladder which is very large, may act as a resonator; while in the herring, the extreme narrowness of the passages which connect the air-bladder with the ear renders it difficult to suppose that the organ can have any such function.

In addition to the singular connection of the ear with the exterior by the roundabout way of the air-bladder, there are membranous spaces in the walls of the skull by which vibrations can more directly reach the herring's ear. And there is no doubt that the fish is very sensitive to such vibrations. In a dark night, when the water is phosphorescent, or, as the fishermen say, there is plenty of "merefire," it is a curious spectacle to watch the effect of sharply tapping the side of the boat as it passes over a shoal. The herrings scatter in all directions leaving streaks of light behind them, like shooting stars.

The herring, like other fishes, breathes by means of the gills—the essential part of which consists of the delicate, highly-vascular filaments, which are set in a double row on the outer faces of each of the gill arches. The venous blood which returns from all parts of the body to be collected in the heart is pumped thence into the gills, and there exchanges its excess of carbonic acid gas for the gaseous oxygen which is dissolved in sea-water. The freedom of passage of the water, and the great size and delicacy of the gills, facilitate respiration when the fish is in its native element; but the same peculiarities permitting of the rapid drying and coherence of the gills, and thus bringing on speedy suffocation, render its tenure of life, after removal from the water, as short as that of any fish. It may be observed, in passing, that the wide clefts behind the gill-covers of the herring have some practical importance, as the fish, thrusting its head through the meshes of the drift-net, is caught behind them and cannot extricate itself. In the herring, the upper end of the last gill cleft is not developed into a sac or pouch, such as we shall find in some of its near neighbors.

The only other organs of the herring which need be mentioned at present, are the milt and roe, found in the male and female herring respectively.

These are elongated organs attached beneath the air-bladder; which lie one on each side of the abdominal cavity, and open behind the vent by an aperture common to the two. The spermatic fluid of the male is developed in the milt and the eggs of the female in the roe. These eggs, when fully formed, measure from one-sixteenth to one-twenty-fifth of an inch in diameter; and, as, in the ripe female, the two roes or ovaries stretch from one end of the abdominal cavity to the other, occupying all the space left by the other organs, and distending the cavity, the number of eggs which they contain must be very great. Probably 10,000 is an under estimate of the number of ripe eggs shed in spawning by a moderate-sized female herring. But I think it is safer than the 30,000 of some estimates, which appear to me to be made in forgetfulness of the very simple anatomical considerations that the roe consists of an extensive vascular framework as well as of eggs; and, moreover, that a vast number of the eggs which it contains remain immature, and are not shed at the time of spawning.

In this brief account of the structure of the herring I have touched only on those points which are peculiarly interesting, or which shall bear upon what I shall have to say by and by. An exhaustive study of the fish from this point of view alone would require a whole course of lectures to itself.

The herring is a member of a very large group of fishes spread over all parts of the world, and termed that of the *Clupeidæ*, after *Clupea*, the generic name of the herring itself. Our herring, the *Clupea harengus*, inhabits the White Sea and perhaps some parts of the Arctic Ocean, the temperate and colder parts of the Atlantic, the North Sea, and the Baltic, and there is a very similar, if not identical, species in the North Pacific. But it is not known to occur in the seas of southern Europe, nor in any part of the intertropical ocean, nor in the southern hemisphere.

There are four British fishes which so closely resemble herrings, externally and internally, that, though practical men may not be in any danger of confounding them, scientific zoölogists have not always succeeded in defining their differences. These are the sprat, the allice and twaite shads, and the pilchard.

The sprat comes nearest; indeed young herrings and sprats have often been confounded together, and doubts have been thrown on the specific distinctness of the two. Yet if a sprat and a young herring of the same size were placed side by side, even their external differences leave no doubt of their distinctness. The sprat's lower jaw is shorter; the shields in the middle of the belly have a sharper keel, whence the ventral edge is more like a saw; and the ventral fin lies vertically under the front edge of the dorsal fin, or even in front of it; while in the herring, though the position of the ventral fin varies a little, it lies more or less behind the front margin of the dorsal fin. The anal fin is of the same length as the dorsal in the herring, longer than the dorsal in the sprat. But the best marks of distinction are the absence of vomerine teeth in the sprat, and the smaller number of pyloric cæca which do not exceed nine, their openings being disposed in a single longitudinal series.

Shads and pilchards have a common character by which they are very easily distinguished from both sprat and herring. There is a horizontal fold of scaly skin on each side of the tail above and below the middle line. Moreover they have no teeth in the inside of the mouth, and their pyloric cæca are very numerous—a hundred or more—their openings being disposed five or six in a row.

The shads have a deep narrow notch in the middle line of the upper jaw, which is absent in the pilchard. The intestine of the shad is short and straight, like that of the herring; while that of the pilchard is long and folded several times upon itself.

Both of these fishes, again, possess a very curious structure, termed an accessory branchial organ, which is found more highly developed in other fishes of the herring family, and attains its greatest development in a fresh-water fish, the *Heterotis*, which inhabits the Nile. This organ is very rudimentary in the shad (in which it was discovered by Gegenbaur*), but it is much larger in the pilchard, in which,

* A lecture delivered by Prof. Huxley at the National Fishery Exhibition, Norwich, April 21, 1881.—*Nature.*

* See Müller. "Ueber Fische welche Töne von sich geben." *Archiv für Physiologie*, 1857, p. 267. The herring is not mentioned in Müller's list of vocal fishes.

* "Ueber das Kopfskelet von *Alepocephalus rostratus*," *Morphologisches Jahrbuch*, Bd. iv., Suppl. 1878

so far as I know, it has not heretofore been noticed. In *Chanos* and several other Clupeoid fishes it becomes coiled upon itself, and in *Heterotis* the coiled organ makes many turns. The organ is commonly supposed to be respiratory in function; but this is very doubtful.

Herrings which have attained maturity and are distended by the greatly enlarged milt or roe are ready to shed the contents of these organs, or, as it is said, to spawn. In 1862, we found a great diversity of opinion prevailed as to the time at which this operation takes place, and we took a great deal of trouble to settle the question, with the result which is thus stated in our report:

"We have obtained a very large body of valuable evidence on this subject, derived partly from the examination of fishermen and of others conversant with the herring fishery; partly from the inspection of the accurate records kept by the fishery officers at different stations, and partly from other sources; and our clear conclusion from all this evidence is, that the herring spawns at two seasons of the year, in the spring and in the autumn. We have hitherto met with no case of full or spawning herrings being found, in any locality, during what may be termed the solstitial months, namely, June and December; and it would appear that such herrings are never (or rarely) taken in May or the early part of July, in the latter part of November, or the early part of January. But a spring spawning certainly occurs in the latter part of January, in February, in March, and in April; and an autumn spawning in the latter part of July, in August, September, October, and even as late as November. Taking all parts of the British coast together, February and March are the great months for the spring spawning, and August and September for the autumn spawning. It is not at all likely that the same fish spawn twice in the year; on the contrary, the spring and autumn shoals are probably perfectly distinct; and if the herring, according to the hypothesis advanced above, come to maturity in a year, the shoals of each spawning season would be the fry of the twelvemonth before. However, no direct evidence can be adduced in favor of this supposition, and it would be extremely difficult to obtain such evidence."*

I believe that these conclusions, confirmatory of those of previous careful observers† are fully supported by all the evidence which has been collected, and the fact that this species of fish has two spawning seasons, one in the hottest and one in the coldest months of the year, is very curious.

Another singular circumstance connected with the spawning of the herring is the great variety of the conditions, apart from the temperature, to which the fish adapts itself in performing this function. On our own coasts, herrings spawn in water of from ten to twenty fathoms, and even at greater depths, and in a sea of full oceanic saltness. Nevertheless herrings spawn just as freely, not only in the narrows of the Baltic, such as the Great Belt, in which the water is not half as salt as it is in the North Sea and in the Atlantic, but even in such long inlets as the Schlei in Schleswig, the water of which is quite drinkable and is inhabited by freshwater fish. Here the herrings deposit their eggs in two or three feet of water; and they are found, along with the eggs of freshwater fish, sticking in abundance to such freshwater plants as *Potamogeton*.

Nature seems thus to offer us a hint as to the way in which a fish like the shad, which is so closely allied to the herring, has acquired the habit of ascending rivers to deposit its eggs in purely fresh water.

If a full female herring is gently squeezed over a vessel of sea-water, the eggs will rapidly pour out and sink to the bottom, to which they immediately adhere with so much tenacity that, in half an hour, the vessel may be inverted without their dropping out. When spawning takes place naturally the eggs fall to the bottom and attach themselves in a similar fashion. But, at this time, the assembled fish dart wildly about, and the water becomes cloudy with the shed fluid of the milt. The eggs thus become fecundated as they fall, and the development of the young within the ova sticking to the bottom commences at once.

The first definite and conclusive evidence as to the manner in which herring spawn is attached and becomes developed that I know of, was obtained by Prof. Allman and Dr. MacBain in 1862,‡ in the Firth of Forth. By dredging in localities in which spent herring were observed on the 1st of March, Professor Allman brought up spawn in abundance at a depth of fourteen to twenty-one fathoms. It was deposited on the surface of the stone, shingle, and gravel, and on old shells and coarse shell sand, and even on the shells of small living crabs and other crustacea, adhering tenaciously to whatever it had fallen on. No spawn was found in any other part of the Forth; but it continued to be abundant on both the east and west sides of the Isle of Man up to the 13th of March, at which time the incubation of the ovum was found to be completed in a great portion of the spawn, and the embryos had become free. On the 25th scarcely a trace of spawn could be detected, and nearly the whole of the adult fish had left the Forth.

Prof. Allman draws attention to the fact "that the deposit of spawn, as evidenced by the appearance of spent herrings, did not take place till about sixty-five days after the appearance of the herring in the Firth," and arrives at the conclusion that "the incubation probably continues during a period of between twenty-five to thirty days," adding, however, that the estimate must for the present be regarded as only approximative. It was on this and other evidence that we based our conclusion that the eggs of the herring, "are hatched in at most from two to three weeks after deposition."

Within the last few years a clear light has been thrown upon this question by the labors of the West Baltic Fishery Commission, to which I have so often had occasion to refer.§ It has been found that artificial fecundation is easily practiced, and that the young fish may be kept in aquaria for as long as five months. Thus a great body of accurate information, some of it of a very unexpected character, has been obtained respecting the development of the eggs, and the early condition of the young herring.

It turns out that, as is the case with other fishes, the period of incubation is closely dependent upon warmth. When the water has a temperature of 53° Fahrenheit, the eggs of the herring hatch in from 6 to 8 days; the average being seven days. And this is a very interesting fact when we bear in mind the conclusion to which the inquiries of the Dutch meteorologists, and, more lately, those of the Scottish Meteorological Society, appear to tend, namely, that the shoals prefer water of about 55°. At 50° Fahrenheit, the period of incubation is lengthened to eleven days; at 46° to fifteen days; and at 38° it lasts forty days. As the Forth is usually tolerably cool in the month of March, it is probable that Prof. Allman's estimate comes very near the truth for the particular case which he investigated.

The young, when they emerge from the egg, are from one-fifth to one-third of an inch in length, and so extremely unlike the adult herring that they may properly be termed larvæ. They have enormous eyes and an exceedingly slender body, with a yelk bag protruding from its forepart. The skeleton is in a very rudimentary condition; there are no ventral fins; and instead of separate dorsal, caudal, and anal fins, there is one continuous fin extending from the head along the back, round the tail, and then forward to the yelk bag. The intestine is a simple tube, ciliated internally; there is no air-bladder, and no branchiæ are yet developed. The heart is a mere contractile vessel, and the blood is a clear fluid without corpuscles. At first the larvæ do not feed, but merely grow at the expense of the yelk which gradually diminishes.

Within three or four days after hatching, the length has increased by about half the original dimensions, the yelk has disappeared, the cartilaginous skeleton appears, and the heart becomes divided into its chambers; but the young fish attains nearly double its first length before blood corpuscles are visible.

By the time the larva is two-thirds of an inch long (a length which it attains one month after hatching), the primitive median fin is separated into dorsal, caudal, and anal divisions, but the ventral fins have not appeared. About this period the young animal begins to feed on small crustacea; and it grows so rapidly that, at two months, it is 1¼ inches long, and, at three months, has attained a length of about two inches.

Nearly up to this stage the elongated scaleless little fish retains its larval proportions; but, in the latter part of the third month, the body rapidly deepens, the scales begin to appear, and the larva passes into the "imago" state—that is, assumes the form and proportions of the adult, though it is not more than two inches long. After this, it goes on growing at the same rate (11 millimeters, or nearly half an inch) per month, so that, at six months old, it is as large as a moderate sized sprat.

The well-known "whitebait" of the Thames consists, so far as I have seen, almost exclusively of herrings, under six months old, and as the average size of the whitebait increases, from March and April onwards, until they become suspiciously like sprats in the late summer, it may be concluded that they are the progeny of herrings which spawned, early in the year, in the neighborhood of the estuary of the Thames, up which these dainty little fish have wandered. Whether it is the general habit of young herring, even of those which are spawned in deep water, to migrate into the shallow parts of the sea, or even into completely fresh waters, when such are accessible, is unknown.

In the Report on Trawling (1863) we observe:

"It is extremely difficult to obtain any satisfactory evidence as to the length of time which the herring requires to pass from the embryonic to the adult or *full* condition. Of the fishermen who gave any opinion on this subject, some considered that a herring takes three, and others that it requires seven, years to attain the full or spawning condition; others frankly admitted that they knew nothing about the matter; and it was not difficult, by a little cross-examination, to satisfy ourselves that they were all really in this condition, however strongly they might hold by their triennial or septennial theories. Mr. Yarrell and Mr. Mitchell suppose with more reason that herring attain to full size and maturity in about eighteen months.

"It does not appear, however, that there is any good evidence against the supposition that the herring reaches its spawning condition in one year. There is much reason to believe that the eggs are hatched in at most, from two to three weeks after deposition, and that in six or seven weeks more (that is at most ten weeks from the time of laying the eggs) the young have attained three inches in length. Now it has been ascertained that a young smolt may leave a river and return to it again in a couple of months increased in bulk eight or ten fold, and as a herring lives on very much the same food as a smolt, it appears possible that it should increase in the same rapid ratio. Under these circumstances nine months would be ample time for it to enlarge from three to ten or eleven inches in length. It may be fairly argued, however, that it is not very safe to reason analogically from the rate of growth of one species of fish to that of another; and it may be well to leave the question whether the herring attains its maturity in twelve, fifteen, or sixteen months open, in the tolerably firm assurance that the period last named is the maximum."

On comparing these conclusions with the results of the careful observations of the Baltic Commissioners, it appears that we somewhat over-estimated the rate of growth of the young herring, and that the view taken by Yarrell and Mitchell is more nearly correct. For supposing that the rate of growth after six months continues the same as before, a herring twelve months old will be nearly six inches long, and at eighteen months eight or nine inches. But full herrings may be met with little more than seven inches long, and they are very commonly found not more than nine inches in length.*

Fishermen distinguish four states of the herring. Fry or sile, when not larger than sprats; maties, when larger than this, with undeveloped roe or milt; full fish, with largely developed roe or milt; and spent or shotten fish, which have recently spawned.

Herring fry of the size of sprats are distinguished from full fish not merely by their size, but in addition by the very slight development of the milt or roe, and by the accumulation of fat in the abdominal cavity. Bands of fat are found in the mesentery alongside the intestine, and filling up the interspaces between the pyloric cæca.

Maties (the name† of which is a corruption of the Dutch word for a maiden) resemble the fry in these particulars; but if they are well fed, the deposit of fatty and other nutritive matter takes place not only about the abdominal viscera, but also beneath the skin and in the interstices of the flesh. Indeed, when nourishment is abundant, this infiltration of the flesh with fat may go so far that the fish cannot readily be preserved and must be eaten fresh. The singularly delicate Loch Fyne herrings are in this condition early in the season. When the small crustaceans, on which the maties chiefly feed, are extremely abundant the fish gorge themselves with them to such an extent that the conical crop becomes completely distended, and the Scotch fishermen give them the name of "gut-pock" herrings, as much as to say pouch-gutted fish, and an absurd notion is current that these herrings are diseased. However, the "gut pock" herrings differ from the rest only in having their pouch full instead of empty, as it commonly is.

As the fish passes from the matie to the full condition, the milt and roe begin to grow at the expense of the nutriment thus stored up; and, as these organs become larger and occupy more and more space in the abdominal cavity, the excess of nutritious substance is transferred to them. The fatty deposit about the intestine and pyloric cæca gradually disappears and the flesh becomes poorer. It would appear that by degrees the fish cease to feed at all. At any rate, there is usually no food in the stomach of a herring which approaches maturity. In all these respects there is the closest resemblance between the history of the herring and that of other fishes such as the salmon—the part corresponding to the herring fry or sile, the grilse and the "clean fish" of larger size to the maties.

At length spawning takes place, the accumulated nutrition, transformed into eggs or spermatic fluid, is expelled, and the fish is left in that lean and depauperated state which makes a "shotten herring" proverbial. In this condition it answers to the salmon "kelt," and the milt or roe are now shrunk and flaccid and can be blown up with air like empty bags. If the spent fish escapes its myriad enemies, it doubtless begins to feed again and once more passes into the matie state in preparation for the next breeding season. But the nature of this process of recuperation has yet to be investigated.

When they have reached the matie stage, the herrings, which are at all times gregarious, associate together in conspicuous assemblages, which are called shoals. These are sometimes of prodigious extent—indeed eight or nine miles in length, two or three in breadth, with an unknown depth, are dimensions which are credibly asserted to be sometimes attained. In these shoals the fish are closely packed, like a flock of sheep straying slowly along a pasture, and it is probably quite safe to assume that there is at least one fish for every cubic foot of water occupied by the shoal. If this be so, every square mile of such shoal, supposing it to be three fathoms deep, must contain more than 500,000,000 herrings. And when it is considered that many shoals approach the coasts, not only of our own islands, but of Scandinavia and the Baltic, and of Eastern North America, every spring and autumn, the sum total of the herrings which people our seas surpasses imagination.

If you read any old and some new books on the natural history of the herring, you will find a wonderful story about the movements of these shoals. How they start from their home in the Polar Seas, and march south as a great armada which splits into minor divisions—one destined to spawn on the Scandinavian, and one on our own shores; and how, having achieved this spawning raid, the spent fish make their way as fast as they can back to their Arctic refuge, there to repair their exhausted frames in domestic security. This story was started in the last century, and was unfortunately adopted and disseminated by our countryman, Pennant. But there is not the least proof that anything of the kind takes place, and the probabilities are wholly against it. It is, for example, quite irreconcilable with the fact that herring are found in cods' stomachs all the year round. And the circumstance to which I have already adverted, that practiced eyes distinguish local breeds of herrings, though it does not actually negative the migration hypothesis, is very much against it. The supposition that the herring spawn in the north in the early spring, and in the south in the autumn, fitted very well into the notion that the vanguard of the migrating body of herrings occupied the first spawning ground it reached, and obliged the rest of the horde to pass on. But, as a matter of fact, the northern herrings, like the southern, have two spawning times; or perhaps it would be more correct to say that the spawning time extends from autumn to spring, and has two maxima—one in August-September, and one in February-March.

Finally, there is no evidence that herrings are to be met with in the extreme north of their range, at other times or in greater abundance than they are to be found elsewhere.

In the matter of its migration, as in other respects, the herring compares best with the salmon. The ordinary habitation of both fishes is, no doubt, the moderately deep portion of the sea. It is only as the breeding time draws near that the herrings (not yet advanced beyond the matie state) gather together toward the surface and approach the land in great shoals for the purpose of spawning in relatively or absolutely shallow water. In the case of the herring of the Schlei, we have almost the connecting link between the exclusively marine ordinary herring and the river-ascending salmon.

The records of the herring fisheries are, for the most part, neither very ancient nor (with the exception of those of the Scotch Fishery Board) very accurately kept; and, from the nature of the case they can only tell us whether the fish in any given year were readily taken or not, and that may have very little to do with the actual strength of the shoals.

However, there is historical evidence that, long before the time of Henry the First, Yarmouth was frequented by herring fishers. This means that, for eight centuries, herrings have been fished on the English coast, and I cannot make out, taking one year with another, in recent times, that there has been any serious fluctuation in their numbers. The number captured must have enormously increased in the last two centuries, and yet there is no sign of diminution of the shoals.

In 1864, we had to listen to dolorous prophecies of the coming exhaustion of the Scotch herring fisheries. The fact that the returns showed no falling off was ascribed to the improvement of the gear and methods of fishing, and to the much greater distances to which the fishermen extend their operations. Yet what has really happened? The returns of subsequent years prove, not only that the average cure of the decade 1869–1878 was considerably greater than that of the previous decade, but that the years 1874 and 1880 are absolutely without parallel in the annals of the Scotch herring fishery, a million barrels having been cured in the first of these years, and a million and a half in 1880. In the decade 1859–1868, the average was 670,000 barrels, and the highest 830,000.

* "Report of the Royal Commission on the Operation of the Acts relating to Trawling for Herrings on the Coast of Scotland 1863." p. 28.

† Brandt and Ratzeburg for example, in 1833 strongly asserted that the herring has two spawning seasons.

‡ "Report of the Royal Commission on the Operation of the Acts relating to Trawling for Herring on the Coast of Scotland, 1863."

§ See the four valuable memoirs, Kupffer, "Ueber Laichen und Entwickelung des Herings in der westlichen Ostsee;" *Idem*, "Die Entwickelung des Herings im Ei;" Meyer, "Beobachtungen über den Wachsthum des Herings;" Heincke, "Die Varietäten des Herings," which are contained in the *Jahresbericht der Commission in Kiel für* 1874 75–76—1878. Widegren's essay "On the Herring," 1871, translated from the Danish in U. S. Commission Reports, 1873–75, also contains important information.

* Ljungman ("Preliminary Report on Herring and Herring Fisheries on the West Coast of Sweden," translated in U. S. Commission Report, 1873–75), speaks of full herrings ready to spawn only 100-110 mm. (4 to 4½ in.) long, as observed by himself.

† "Halecum intestina non modo multa gaudere obesitate, sed et totum corpus eo adeo esse impletum ut aliquando cum discinditur, pinguedo ex cultro defluat, et præsertim eo quidem tempore ubi halecum lactes aut ova crescere primum incipiunt, unde nostrates eos *Maatgens-Haringen* dicere solent."—A. v. Leeuwenhoek, "Arcana Naturæ," Ep. xcvii. (1696)

Leeuwenhoek also mentions having heard of "gut pock" herrings from Scotch fishermen.

In dealing with questions of biology, *à priori* reasoning is somewhat risky, and if any one tells me "it stands to reason" that such and such things must happen, I generally find reason to doubt the safety of his standing.

It is said that "it stands to reason" that destruction on such a prodigious scale as that effected by herring fishers must tell on the supply. But again let us look at the facts. It is said that 2,500,000,000, or thereabouts, of herrings, are every year taken out of the North Sea and the Atlantic. Suppose we assume the number to be 3,000,000,000, so as to be quite safe. It is a large number, undoubtedly, but what does it come to? Not more than that of the herrings which may be contained in one shoal, if it covers half a dozen square miles—and shoals of much larger size are on record. It is safe to say that, scattered through the North Sea and the Atlantic, at one and the same time, there must be scores of shoals, any one of which would go a long way toward supplying the whole of man's consumption of herrings. I do not believe that all the herring fleets taken together destroy 5 per cent. of the total number of herrings in the sea in any year, and I see no reason to swerve from the conviction my colleagues and I expressed in our report, that their destructive operations are totally insignificant when compared with those which, as a simple calculation shows, must regularly and normally go on.

Suppose that every mature female herring lays 10,000 eggs, that the fish are not interfered with by man, and that their numbers remain approximately the same, year after year, it follows that 9,998 of the progeny of every female must be destroyed before they reach maturity. For if more than two out of the 10,000 escape destruction, the number of herrings will be proportionately increased; or, in other words, if, the average strength of the shoals which visit a given locality is to remain the same year by year, many thousand times the number contained in those shoals must be annually destroyed. And how this enormous amount of destruction is effected will be obvious to any one who considers the operations of the fin-whales, the porpoises, the gannets, the gulls, the codfish, and the dogfish, which accompany the shoals, and perennially feast upon them; to say nothing of the flatfish, which prey upon the newly-deposited spawn; or of the mackerel and the innumerable smaller enemies which devour the fry in all stages of their development. It is no uncommon thing to find five or six—nay, even ten or twelve—herrings in the stomach of a codfish,* and, in 1863, we calculated that the whole take of the great Scotch-herring fisheries is less than the number of herrings which would in all probability have been consumed by the codfish captured in the same waters, if they had been left in the sea.†

Man, in fact, is but one of a vast co-operative society of herring catchers, and the larger the share he takes, the less there is for the rest of the company. If man took none, the other shareholders would have a larger dividend and would thrive and multiply in proportion, but it would come to pretty much the same thing to the herrings.

As long as the records of history give us information, herrings appear to have abounded on the east coast of the British Islands, and there is nothing to show, so far as I am aware, that, taking an average of years, they were ever either more or less numerous than they are at present. But in remarkable contrast with this constancy, the shoals of herrings have elsewhere exhibited a change capriciousness—visiting a given locality for many years in great numbers, and then suddenly disappearing. Several well-marked examples of this fickleness are recorded on the west coast of Scotland; but the most remarkable is that furnished by the fisheries of Bohüslan, a province which lies on the south-western shore of the Scandinavian peninsula. Here a variety known as the "old" or "great" herring, after being so extremely abundant, for about sixty years, as to give rise to a great industry, disappeared in the year 1808, as suddenly as they made their appearance, and have not since been seen in any number.

The desertion of their ordinary grounds by the herring has been attributed to all imaginable causes, from fishing on a Sunday to the offense caused to the fish by the decomposing carcasses of their brethren, dropped upon the bottom out of the nets. The truth is that absolutely nothing is known on the subject; and that little is likely to be known, until careful and long continued meteorological and zoological observations have furnished definite information respecting the changes which take place in the temperature of the sea, and the distribution of the pelagic crustacea which constitute the chief food of the herring shoals. The institution of systematic observations of this kind is an object of international importance, toward the attainment of which the British, Scandinavian, Dutch, and French Governments might wisely make a combined effort.

A great fuss has been made about trawlers working over the spawning grounds of the herring. "It stands to reason," we were told, that they must destroy an immense quantity of the spawn. Indeed this looked so reasonable, that we inquired very particularly into a case of the alleged malpractice which was complained of on the east coast of Scotland, near Pittenweem. Off this place there is a famous spawning ground known as the Traith Hole, and we were told that the trawlers worked vigorously over the spot immediately after the herring had deposited their spawn. Of course our first proceeding was to ask the trawlers why they took the trouble of doing what looked like wanton mischief. And their answer was reasonable enough. It was to catch the prodigious abundance of flat-fish which were to be found on the Traith at that time. Well, then, why did the flat-fish congregate there? Simply to feed on herring eggs, which seem to be a sort of flat-fishes' caviare. The stomachs of the flat-fish brought up by the trawl were, in fact, crammed with masses of herring eggs.

Thus every flat-fish caught by the trawl was an energetic destroyer of herring arrested in his career. And the trawling, instead of injuring the herring, captured and removed hosts of their worst enemies. That is how "it stood to reason" when one got to the bottom of the matter.

I do not think that any one who looks carefully into the subject will arrive at any other conclusion than that reached by my colleagues and myself: namely, that the best thing for governments to do in relation to the herring fisheries is to let them alone, except in so far as the police of the sea is concerned. With this proviso, let people fish how they like, as they like, and when they like. At present, I must repeat the conviction we expressed so many years ago, that there is not a particle of evidence that anything man does has an appreciable influence on the stock of herrings. It will be time to meddle, when any satisfactory evidence that mischief is being done is produced.

* In his valuable Report on the Salt Water Fisheries of Norway (1877), Prof. Sars expresses the belief that full-grown codfishes feed chiefly, if not exclusively, on herrings.

† In 1879 rather more than 5,000,000 cod, ling, and hake, were taken by the Scottish fishermen. Allowing each only two herrings a day, these fishes would have consumed more than three thousand five hundred million of herrings in a year. As to the Norwegian fisheries, 20,000,000 codfishes are said to be taken annually by the Lofoden fishermen alone.

THE SHAD FISHERY.

"So you have come after that 'shad story,' have you?" remarked Mr. William Fuller of the Long Wharf Fish Company of New Haven, Conn., a day or two ago, as a representative of the *Sea World* entered that gentleman's office and announced his errand. "Well, to get at once to business," began Mr. Fuller, "I would say that I have been engaged in the southern shad fishing for nine seasons, although that was a good many years ago. When I was a young man I was a printer by trade, and I engaged in shad fishing for a number of years as a means of recuperating my health, and also because I could make more money in the winter and early spring months at the business than I could by sticking to my case. My first trip was in 1837, when I went out in one of the New York and Savannah packets. We did not know then that shad could be taken in the St. John's River, Florida. The facts are that shad are first found on the Florida rivers which have their outlets in the Atlantic Ocean, and are never found on the Gulf side.

"Oh, I don't know the reason for this, but it's a fact. The St. John's River is a favorite haunt for this noble fish. As I have said, the first shad of the season are taken in Florida waters. As the season advances, in their migration north, shad are next found in St. Mary's and Altahama rivers, Georgia. The Altahama is about sixty miles southwest of Savannah. They soon get into the Ogeeche and Savannah rivers. You will soon afterward find them at Georgetown, S. C. At Charleston there is not river enough to afford attraction to the shad and but few get up to the city. The Albemarle and Palmico Sounds and tributaries in North Carolina, furnish splendid spawning grounds, and the shad resort thither in immense numbers. These waters afford very fine fishing in the season, and large quantities are taken, a major portion of the northern markets being supplied therefrom during the early part of the fishing. From North Carolina waters shad next pass up to the Capes of Virginia and into the Chesapeake and tributary rivers. In their migrations they are next found at the Capes of the Delaware on their journey to the head waters of the great rivers. That great fishing-ground for shad—the North River—is next invaded, and in turn the Connecticut River. A small number resort to the Thames River, but for some reason the number is not very large. Shad fishing in the Merrimack River is a very profitable occupation, the catch going to the Boston market. In June we find shad in the Penobscot, Kennebec, and other rivers of Maine, and that is about the last of the catch. They don't catch many in the provinces, and it would appear that the shad leave the coast after getting that far north. My theory regarding the migration of shad is this: They apparently move around in an immense circle as it were, the great schools gradually working north as the temperature of the water becomes right for them. Shad demand water of a uniform temperature, and as the water changes in temperature so they change their base. Moving in vast schools miles and miles out at sea, as I have said, they turn toward the shore and into the rivers as they become ready to spawn. After the spawning season the old shad go out to sea to their feeding grounds instead of working north. This is proved conclusively from the fact that poor shad are never taken going up the rivers. As they approach the north-eastern shores of Maine they apparently strike out to sea, thus completing the big circle that I spoke of. This is my theory, the result of long years of study of this migratory fish. The temperature of the water in Maine during the month of July is never so warm as it is here. From this it would appear that they go as far north as the temperature of the water will admit, and then strike off the coast and out to sea. In the winter shad remain off in the Gulf Stream and vicinity, where the temperature suits them.

"No, I never heard of any shad being caught out at sea, although I believe it would be possible could the necessary appliances for deep sea fishing be employed. In the winter they probably remain in deep water—say a hundred fathoms or so. The Fish Commission have discovered some of the characteristic habits of shad, but I believe nothing definite is known as to their propagation and habits in the great ocean depths.

"There are several ways of catching shad, the methods depending on the locality. The old method of hauling the seine on the shore is still employed in some sections of the country. Another way is by means of the drifting gill nets, as in salmon fishing. The net is allowed to drift down the stream or river, on to the shad when they are securely 'gilled.' Only large and fine fish are caught by this method, the smaller ones easily escaping through the meshes. Then there are the stationary nets secured to poles driven securely in the bed of the river. These nets are generally square, and are sunk twenty feet or so below the surface of the river allowing vessels to go over them without ripping them up. The poles yield as the vessel goes by, and no damage is inflicted to vessel or fishing gear. These nets are very largely used on the North River, and 'shad poles' may be seen all over the surface of the water like miniature forests. Along Long Island Sound pounds or traps are employed, a long string of piles being driven at proper distances apart, from which the nets or seines are stretched.

"Down on the Savannah River, where, as I said, I followed the fishery for nine seasons, the water is thick and we could catch the shad either day or night. We would catch from 2,000 to 3,000 fish in a season. We used three and sometimes four gill nets. The first, which were disposed of by the piece or hundred, found a ready sale right there at from $12 to $20 per hundred. In later years the catch has been forwarded to the New York market.

"Oh, yes; they are caught very early. The earliest that I ever caught a shad down there was December 20. They are taken in small numbers in Florida as early or even earlier than that. The largest number I ever caught by myself in a single day was 200. One hundred fish are called a good day's work, although I have caught that number in an hour. Then again for whole days you won't see a half dozen, the catch depending upon the number running. You cannot depend upon them, and shad fishing is varied enough as regards the catch. They don't stay long in any one place. When they come in from sea they are ready to spawn, and reach the spawning ground just as quickly as possible.

"I don't know how many fry one fish would spawn, but probably 100,000. But mind you only a small portion mature. The enemies of the small fry are legion in numbers, and their implacable enemies exterminate them by the million. I don't suppose that more than one in a thousand mature, and yet isn't it a wonder that shad are as plentiful as they are? The spawn when shed adheres to various substances, and the propagation goes on apace. In the first place, the fry when very young are gobbled up in large numbers by minnows, which abound in southern rivers in very large quantities. In fact the waters are fairly alive with them. The fry are exceedingly tender when hatched, and a great many are swept away and destroyed by freshets. Well, we will say that one-half the fry have been destroyed by these agencies. Well, then, they have to contend with pickerel, bass, perch, pike, and like fish of this tribe, who eat them up by the thousand. These are very greedy and voracious fishes, and they have a fine living off the young and tender fry during the short season that they run down to sea. After taking chances with the pike, bass, perch, etc., they are obliged to run the gauntlet with that pirate fish, the remorseless bluefish, which lay in wait at the mouth of the rivers, destroying multitudes of the shad fry as they are about to go to sea. After escaping all these enemies the troubles of the young fry are not ended, for there are those greedy fellows of the deep—the remorseless shark, the porpoise, and other large deep water fishes which consume very many.

"There are a great many islands in the Savannah River. During my stay I lived in a shanty on Hutchinson's Island on Back River. The ship channel runs on the western side. It is deep and but twenty rods wide, the greater part of the water flowing through Back River on the South Carolina side. Some of these islands are very productive. The Sea Islands, which are farther down, are exceedingly rich in their products, the principal crops being the famous Sea Island cotton, sugar cane, corn, and sweet potatoes. Some of the islands are diked three feet high to keep the river from submerging them, some of the islands being flat.

THE RELATIVE FOOD VALUE OF FISH.

IN connection with a paper read before the Fish Culturists' Association, Professor Atwater distributed a table of analyses showing the nutritive qualities of various forms of food, as follows:

Composition and Valuation of Animal Foods (Valuation of Medium Beef Assumed as 100).	Total Per Cent Edible Solids (Actual Nutritive Materials in Sample).	Nutritive Valuation.
Meat.		
Beef (lean)	—	91·3
Beef (medium)	—	100 0
Beef (fat)	—	112 0
Veal (fat)	—	92 4
Mutton (medium)	—	86·6
Pork (fat)	—	116·0
Smoked beef	—	146·0
Smoked ham	—	157·0
Game, Fowl, etc.		
Venison	—	88·8
Hen	—	93·9
Duck	—	104·0
Milk, Eggs, etc.		
Cow's milk	—	23·8
Cow's milk (skimmed)	—	18·5
Cow's milk (cream)	—	56·1
Butter	—	124·0
Cheese (skimmed milk)	—	159·0
Cheese (fat)	—	151·0
Cheese (very fat)	—	103·0
Hen eggs	—	72·2
Fish (Fresh).		
Halibut	21·45	87·9
Flounder	5·97	82·4
Cod	11·45	6[illegible]·2
Haddock	8 88	7[illegible] 9
Alewives	11·95	86 8
Eels (salt water)	22·50	95 6
Shad	16·29	98·2
Striped bass	8 94	80·4
Yellow pike perch	8·45	80·9
Black bass	9·57	86·5
Mackerel	15 48	90·[illegible]
Bluefish	10 96	[illegible]5·4
Salmon	32·99	[illegible]07·9
Salmon trout	14·38	9[illegible]·7
Brook trout	10·77	84·2
Whitefish	13·69	104·5
Porgy	9·76	85 2
Blackfish	1[illegible]·72	93 9
Red snapper	10 10	90·7
Smelt	1[illegible]·51	75·8
Spanish mackerel	20·65	10·59
White perch	9 41	89·2
Masquallange	12·52	91 8
Herring	11·52	100·4
Sheepshead	11·99	96·9
Turbot	15·61	84·4
Spent Fish (Fresh).		
Salmon (male)	14·87	91·0
Salmon (female)	12·17	80·4
Landlocked salmon (male)	10·97	76·4
Landlocked salmon (female)	10·74	77·7
Prepared Fish.		
Boned cod	30·91	106·9
Salt cod	20 45	102·5
Smoked halibut	31 63	102·2
Smoked herring	28·66	103 2
Canned salmon	29 95	107·2
Salt mackerel	30·97	111·1
Invertebrates.		
Lobster	7·98	50·3
Scallops	17·47	68·8
Oysters (European)	—	21·8

THE DEATH ODOR.—Dr. A. B. Isham, Professor of Materia Medica and Therapeutics in the Cincinnati College of Medicine and Surgery, calls attention in the *American Journal of the Medical Sciences* for April, 1881, to the peculiar ante-mortem odor encountered in many cases at a variable period before the fatal result; in one case he noticed it thirty-three hours before death. The smell is analogous to musk, but is rather more pungent and less diffusible. He is inclined to attribute the phenomenon to the liberation of ammonia and of the peculiar volatile oil (fatty acid) which gives the blood its odor, this liberation being caused by the diminishing vitality of the blood.

GRINDELIA ROBUSTA AS A REMEDY IN ASTHMA.*

By T. M. ROCHESTER, M.D.

THE presentation of this subject to the profession has been delayed purposely for some time, and that for two reasons. In the first place, the writer is but a slight believer in the many much-vaunted *new remedies* with which we are at present deluged; and, secondly, he did not wish to be accused of making a great cry over the successful treatment of a few cases. Some months ago, the *Medical Record*, in giving a list of various new drugs, said that Grindelia Robusta had been before the profession for several years, and did probably, therefore, possess some useful properties, although, as there was no literature on the subject, a great deal of ignorance existed as to its real value. The silence of other observers is sufficient excuse, if one were needed, for the writer simply giving his individual experience with the drug.

It is the object of this paper merely to tell what has been done with, and noticed of the action of Grindelia Robusta.

On taking the Chair of Diseases of Heart and Lungs in one of the dispensaries here some two years and a half ago, I naturally met with quite a number of cases of asthma, and having for some months faithfully tried the various approved plans of treatment, which I had used with more or less—usually less—success in private practice, I determined, simply as an experiment, to see what could be done with Grindelia Robusta. It must be remembered that the majority of cases first treated were of long standing, and among a class of people whose hygienic surroundings were, as a rule, bad, and whose occupations, in some instances, were extremely obnoxious to the disease. Notwithstanding this, however, the result of the treatment was more than gratifying. The writer is not one who is much inclined to talk about *cures*, but in no single instance, and that, too, covering a comparatively large experience, has it failed to effect a prompt and decided relief. Up to the present date, including both private and dispensary practice, I have used it in over sixty cases, of which I have made note, and nearly as many more without any record. It has seemed to be of equal efficacy, whether employed for simple spasmodic or for inflammatory asthma. In two cases of cardiac asthma, when combined with the other remedies, it has relieved the dyspnœa as nothing else would. It is useful both during the paroxysm and in the intervals, although it is to be given differently in the two instances. For the former it should be administered in half drachm doses of the fluid extract every fifteen minutes, until the spasm is relieved. At other times it is to be given in fifteen to twenty drop doses, at intervals of from four to six hours, and continued for from a week to ten days, when, except in very obstinate cases, it will have accomplished what was intended, and the patient will experience relief for a period of six or eight months, and in many cases longer. At the approach of another attack the use of the drug for a few days will be found all that is necessary.

My usual dispensary formula for its administration is as follows:

℞. Potassii bromidi		℥ss.
Fl. ext. Grindeliæ Robustæ,	of each	℥j.
Syr. ipecacuanha,		
Aquæ puræ		℥ij.

M. Sig. Teaspoonful every four hours.

This had better be varied in private practice, as it is decidedly nasty to the taste. In my experience I have rarely had to give more than one bottle of this mixture until after the expiration of the time mentioned above. Grindelia Robusta has also proved of singular benefit in hay asthma. In one case in particular, of this nature, where the patient, a lady, had been a great sufferer from this affection for thirty-eight years, and had tried everything without any relief, it acted like a charm, and I received a note of thanks from her which would have made the fortune of a patent-medicine man.

I have used it now exclusively for all asthmatic affections occurring in my practice for over two years, and have never been disappointed in it. Others may not be so fortunate, as there is a great deal in getting used to any remedy and learning just how to vary its administration and dose for each individual case. The writer's experience, however, is excuse enough for his occupying a portion of your time this evening, and he believes that Grindelia Robusta will prove of very great assistance in a number of what might otherwise have been exceedingly obstinate cases. A number of my friends in the profession have used it and report good success. In one case, in the practice of Dr. McHaughton, where it was given to a child during a paroxysm, although it relieved the dyspnœa, it also seemed to have a decidedly depressant effect. This is the only instance where I have seen or heard of its having this action, and am inclined to think it due in this case to some idiosyncrasy of the patient.

As regards the preparation used, I have always employed the fluid extract, but think that, owing to its unpleasant taste, if there be a solid extract it would be preferable to give it than in pill form. The writer has never, to his knowledge, used the Western preparation of this drug, but finds, on inquiry among his apothecaries, that he has obtained that made by different New York manufacturing druggists.

In conclusion, let me say a few words as to the probable action of Grindelia Robusta. I do *not* believe that it is a specific. My observation of its effects induces me to consider it primarily as an anti-spasmodic, with possibly especial reference to the spasm of the bronchioles. Secondly, it is a stimulant expectorant, and this is probably why, in conjunction with its anti-spasmodic properties, it is so peculiarly useful in inflammatory asthma. Thirdly, it may be regarded, in a certain sense, as a bronchial tonic. Judging from its action, it looks as though it might prove useful in pertussis, but my own experience with it in this affection has not been sufficient to warrant an assertion to that effect. I have used it in a few cases in dispensary practice, and the mothers have told me that the children's paroxysms were not so severe or frequent while taking it, but this is only hearsay evidence.

I have used it, however, with marked benefit, in a great many cases of bronchorrhœa and chronic bronchitis, as an adjuvant to other measures.

It was my intention to have brought up this subject at the time that the treatment of asthma was under discussion by the society, but I was unable to be present at that meeting. The continued use of the drug since that time enables me to speak much more positively as to its efficacy than I could then have done. My experience then would not have warranted more than a suggestion as to its use. At present, however, I feel that I can thoroughly recommend it, as it has proved, in my hands at least, far superior to any of the other remedies or methods of treatment for asthma.

Wishing to make this a fair and impartial statement of the merits or demerits of Grindelia Robusta, so far as its use in any way has come to my knowledge, I will say that I learned yesterday from Dr. S. E. Fuller, since writing the above, that he has tried it in six cases with no apparent benefit except in one case. In this instance, however, the drug acted with marked and decided efficacy. I believe that the doctor has only used it during the paroxysm, which perhaps accounts for his lack of success, as it seems to be more especially useful when given during the intervals, for the purpose of warding off an attack.

* Proceedings of the Medical Society of the County of Kings.

OLEATE OF MERCURY FOR THE HAIR.*

By A. HENRIQUES DE YOUNG, M.D.

I WISH to call your attention in this brief paper to a remedy which I deem a valuable addition to our materia medica; to wit, *oleate of mercury*.

Oleic acid, according to Fowne, is obtained by the saponification olein, the fluid constituent of most natural fats and fixed oils. The oleate is the result of the combination of the oleate with a base. The article dispensed is a solution of the oleate in oleic acid, the latter combining with mercury, bismuth, zinc, lead, atropia, and morphia. They are prepared generally as five or ten per cent solutions, and with the exception of the oleate of zinc, are liquid.

The first use I ever made of the drug was in a case of tinea decalvans or alopecia areata, if we wish to latinize the condition found. The patient, a young girl of sixteen years, of a consumptive family, though strong and healthy herself, noticed, about five years ago, a white streak in the scalp, devoid of hair and covered with a thin scale. This was immediately followed by bald spots appearing all over the head, until complete baldness was threatened. The spots varied in size from half an inch to two inches in diameter, each covered with a thin scurf, which on being removed the skin was found very nearly normal, perhaps slightly congested. Each patch was well defined, the hair ending abruptly at the margin. Matting of the hair occurred in the beginning; then it became lusterless and brittle, the ends split, and it fell out. During the course of the disease, and particularly in the commencement, itching and formication greatly troubled the patient. Various remedies were used, mercurials, copper wash, sulphur, sulphurous acid, and others, all with no result; the scalp in the meanwhile being shaved and attention paid to cleanliness. This state of affairs continued for over five years, new hair springing up only to perish again. Nine months ago I examined the patient and directed her to use a five per cent. solution of oleate of mercury. The hair was shaved off and the oleate rubbed well in every day; in the morning the scalp was well cleansed with Castile soap and water, and the oleate again applied. In the course of a month a great change was noticed, the hitherto bald spots became covered with hair. On again prescribing the remedy, I added as a tonic five grains of the alkaloid quiniæ to the ounce. The hair is now jet black, curly, and thick, and from three to four inches long. The scalp is entirely free from bald spots, and I consider her cured of a malady alike detrimental to her hair and peace of mind.

The cause of this disease is parasitic, and its seat the hair follicles.

Tilbury Fox, in his work, says the fungus in tinea decalvans is "the microsporon audouini. The spores are from the $\frac{1}{25000}$ to the $\frac{1}{5000}$ of an inch, the filaments few, wavy, and devoid of granules. The fungus is sometimes found in the epithelium at the extending edge of the disease. He believes, however, that it often lodges behind, in the empty follicles, attacking the epithelial structures therein and interfering with the proper reformation of the hair."

This case is remarkable on account of its duration and for the shortness of the period in which the cure took place. This, I believe, is due to the rapid penetration and action of the oleate, a property not possessed in the same degree by the ordinary ointments.

I have had happy results in a case of indurated acne of the face occurring in a young man without obvious cause. The disease was of three years' standing, the face being dotted with the pustules and nodules of inflammatory deposit in the skin. Seborrhœa was present to such an extent that it made it difficult to grasp the skin. He had been using the following:—

℞. Liq. potassæ	ʒj.
Aquæ rosæ	℥iv.

M. And applied it several times a day.

I frequently, with the aid of a bistoury, scarified the skin and let out the stagnated blood and broken down sebum. Under this treatment he improved, but still the indurations remained, and for this I ordered equal parts of a five per cent. solution of oleate of mercury and cosmoline. Under its influence the nodules and indurations disappeared, and he is now cured. I have seen the speedy dissolution of enlarged glands when treated with the oleate of mercury.

Mr. John Marshall, of England, who first introduced the article, recommends it for all parasitic skin diseases. He also uses the oleate of mercury and morphia in superficial inflammations, especially of the joints. Bartholow, in his work on therapeutics, says "the oleate is extremely serviceable in syphilitic indurations, but is not advisable when ulceration exists." He further remarks that it promptly produces the constitutional effects of mercury. In my cases the oleate was used for several months, and no ill effects followed.

Dr. Alder Smith, in the *British Medical Journal*, reports a case of tinea sycosis cured by the constant application of a five per cent. solution of oleate of mercury.

Dr. John V. Shoemaker, in a paper, urges its use in eczema, psoriasis, pityriasis, erythema, and herpetic eruptions. He found it an invaluable application for general thinning and loss of hair, and employed the oleate of atropia in arresting the abundant secretion of seborrhœa and in subduing high inflammatory action in some cases of erysipelas. He found in the oleate of bismuth a useful remedy in soothing and relieving the cutaneous irritation of acute specific eruptions, especially scarlatina.

Dr. Shoemaker sums up their advantages as follows: First, they do not decompose, like the ordinary ointments, and act as irritants to the skin. Further, oleic acid possesses absorbent and solvent powers that are more active than the bases of ointments. And lastly, they, being liquid, are better suited for application over the scalp, beard, axillary and pubic regions, as they do not mat together the hair.—*Med. and Surg. Reporter.*

* Read before the James Aitken Meigs Med. Association of Philadelphia.

ON THE FORMATION OF A CHEMICAL COMPOUND OF AMMONIA WITH SILVER BROMIDE.

By J. VINCENT ELSDEN, B.SC. (Lond.), F.C.S.

THE following observations will probably be interesting to many who may be studying the influence of ammonia in emulsion; for, although the results contained in the following lines were obtained by the action of concentrated ammonia solution upon silver bromide in the absence of organic matter, yet it seems probable that similar reactions will occur, to some extent at least, in all cases in which ammonia is added to gelatino-bromide emulsions.

The bromide of silver was prepared by precipitation, and carefully washed by decantation. Its color was then pale yellow; but on placing a quantity into a bottle containing sufficient concentrated ammonia solution (sp. g. 0·880) to dissolve it, the color immediately became white, and remained so, even in full daylight, until the solution was complete.

From this solution of bromide of silver in ammonia, the salt appears to be deposited in at least four distinct modifications; and, in order to explain more clearly under what conditions a true chemical compound of ammonia with silver bromide is capable of being deposited, I have thought it well to describe each of these different forms in the order in which they were observed. All the observations were made with the microscope, and the one-inch objective was employed throughout. The results obtained both by bright daylight and by lamplight were identical.

1. On placing one drop of the original saturated solution, diluted with five drops of water, beneath the microscope, it will be observed that, on evaporation, nearly the whole of the bromide is deposited in the form of *brilliantly-colored transparent crystalline plates* of very perfect and regular forms, among the most frequent of which are the regular hexagon and the equilateral triangle (see Fig. 1).

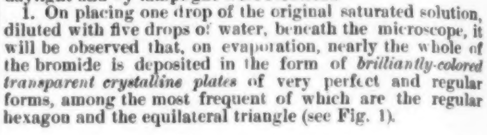

FIG. 1.
Forms of silver bromide deposited from ammonia solution.

The size of the crystals varies considerably from less than $\frac{1}{1000}$ in. to more than $\frac{1}{100}$ in.; but their thickness can scarcely amount to $\frac{1}{20000}$ in., being almost inappreciable beneath a high power of the microscope.

These crystals have various and most beautiful shades of color, both by transmitted and reflected light; they sparkle with great brilliancy, and appear blue, green, yellow, and red indiscriminately. Generally, each crystal has its own color throughout; but sometimes a crystal appears divided into two parts, each with a distinct shade of color, as if it were a twin crystal. Less frequently appear variegated crystals. The crystals have no influence upon polarized light when lying flat; but they appear to be doubly refractive when the rays pass obliquely through them, as if they belonged to the hexagonal system.

The crystals, unlike ordinary bromide of silver, are perfectly stable, even in strong sunlight. When exposed for days to its action they present no difference, either in color, transparency, or brilliancy. Hyposulphite of soda, as well as ammonia, dissolves the crystals, except a thin brown film retaining the original shape, such as would be the case if they consisted of the sub-bromide, as in the equation:

$$Ag_2Br+Na_2S_2O_3=Ag_2S_2O_3+2NaBr+Ag_2$$

Although this view is also supported by the stability of the crystals in daylight, it requires still further confirmation.

2. When the original saturated solution is used, diluted with not more than an equal volume of water, the bromide is deposited in a modification quite distinct from the above. As the evaporation of ammonia goes on, the solution is seen to become filled with square and oblong, transparent, colorless crystalline plates, generally of very perfect form, but sometimes showing regular deviations from their normal shapes, owing probably to imperfect crystallization (see Fig. 2).

FIG. 2.
Forms of crystals deposited from concentrated solutions of silver bromide in ammonia.

The thickness of these plates is about the same as that of those described above. Although perfectly colorless by transmitted light, by reflected light they shine with the most splendid tints of color. Under the action of polarized light they are seen to be strongly dichroic, being alternately light and dark four times in a complete revolution of the crystal between crossed nicols. These crystals are, therefore, doubtless tetragonal. With polarized light they appear generally of a pale lavender color, even by transmitted light.

These crystals are exceedingly unstable, and appear to be incapable of existence in the absence of ammonia; for when evaporation reaches a certain stage, they all disappear and leave nothing but an opaque, brownish residue in their place; but I was able to collect a number of these crystals in a test-tube, which, when inverted, suffered the liquid to be drained off, leaving the crystals dry. They then appeared tolerably stable in diffused daylight, remaining quite unchanged. On warming the tube, even slightly, however, they at once were converted into opaque, yellow bromide of silver, which quickly turned slate-brown in daylight. The same decomposition of the crystals was effected by the addition of water or of acids.

Evidently these crystals consist of a compound of ammonia and silver bromide in a state of very loose chemical combination, the slightest change of conditions being sufficient to dissociate the ammonia and to leave only silver bromide. The action of re-agents upon this substance, to which a formula NH_3AgBr may perhaps be assigned, may be thus represented:

$$NH_3AgBr+H_2O=AgBr+NH_4O$$

while the effect of heat is a simple dissociation.

$$NH_3AgBr=NH_3+AgBr$$

3. In each of these former cases the bromide was deposited by rapid evaporation. If the solution is left for some days to evaporate slowly, the bromide is deposited in neither of the two forms described above, but as solid green cubical crystals, having generally the form of the octahedron, or its combination with the cube. These crystals are perfectly transparent, of great luster, and retain their green color for

some time, even in bright daylight; but they appear to darken slowly, and to undergo a gradual conversion to sub bromide after a prolonged exposure to light. These crystals, which appear to be an artificial form of the mineral bromite, appear to be the final result of deposition from an ammoniacal solution of silver bromide in all cases of slow evaporation.

4. Lastly there appear, generally mixed with the forms previously mentioned, varying quantities of granular bromide, but evidently differing from the original bromide in size as well as in physical properties, being far more prone to decomposition by the action of light.

On the whole, it is evident that silver bromide, deposited from its solution in ammonia, is no longer in the same condition as before its solution. It seems certain, also, that under certain circumstances (2), a definite compound of ammonia with silver bromide is formed. If this be true, silver bromide is capable of retaining ammonia to some extent; and the statement of Rammelsberg, that silver bromide absorbs no ammonia, seems not to be rigorously correct in all cases.

The stability of the colored crystalline plates (1) is interesting; but it would be difficult to decide whether they consist of bromide or sub-bromide. If the latter is the case, we may assume that ammonia has, in some cases, an action upon silver bromide similar to the following:

$$2NH_4O+4AgBr=2Ag_2Br+2NH_4Br+H_2O$$

But it scarcely seems probable that, in the absence of organic matter, ammonia should have this reducing action upon the silver salt. For the present, therefore, it will be sufficient to restate the unmistakable results of the above observations, viz.:

1. That ammonia is capable of forming with silver bromide a definite chemical compound.
2. That it is also capable of transforming silver bromide into a colored, transparent crystalline body, which is stable in strong sunlight.
3. Lastly, that in all cases of deposition from solution in ammonia, the physical condition of the bromide is completely changed.—*Photo News.*

THE BASIC DEPHOSPHORIZING PROCESS.

AT a recent meeting of the Engineers' Society of Western Pennsylvania, held in Library Hall, Pittsburg, December 21, Jacob Reese read a paper on "The Basic Dephosphorizing Process," in which he reviewed all the old processes by which iron and steel have been made, and explained, on technical ground, why dephosphorization did or did not take place in the practice of the said processes. He said that the dephosphorizing problem may be summed up in these words: "The phosphorus must be oxidized to phosphoric acid, P_2O_5, in the presence of a highly basic slag, in order that the acid so formed may unite with and be held by a metallic base as a phosphate, and as silicic acid and carbonic oxide, if present, will reduce the phosphate and return the phosphorus back to the metal, the slag must be sufficiently basic as to engage all the silicic acid as silicates. And in order to avoid the reduction of the phosphate by carbonic oxide, dephosphorization must take place in the absence of CO, which may be secured after the carbon is eliminated."

When the Bessemer converter is furnished with a lime lining, and the metal is blown in the presence of a highly basic slag until the silicon is oxidized to silicic acid, and this acid unites with bases forming silicates, and the blow is continued until the carbonic oxide disappears, and the metal is further blown in the presence of a highly basic slag, and in the absence of free silicic acid and carbon oxide, the phosphorus is rapidly oxidized to P_2O_5, which enters the slag, and, uniting with oxide of iron, remains there as a phosphate of iron ($2FeO,P_2O_5$), and the silicon, carbon, and phosphorus are entirely eliminated from the metal.

The basic dephosphorizing process will produce good steel of all grades from common pig metal, because all foreign matter is eliminated, and the pure iron is then recarbonized to any degree desired. *Fibrous wrought iron* may also be produced from white, mottled, or gray forge pig metal in a basic Bessemer converter, and at much less cost than such metal can be put into muck bars by the puddling process. For these reasons he predicts that the puddling process, which now furnishes over fifteen hundred thousand tons of wrought iron per annum in the United States, will soon be wiped out by the basic process.

Mr. Reese claims that the basic process will produce better spring steel, better plow steel, better steel for cutting tools and polished work, and that basic steel rails, containing 0·60 to 0·75 carbon, will be stronger, tougher, and will wear double the tonnage of steel rails now made by the Bessemer process containing silicon and other impurities. As the metal is converted to wrought iron or steel by the basic process while it is in a fluid state, it is manipulated exclusively by automatic action, hence the advantage heretofore possessed by England of cheap labor will disappear to a great extent; therefore he says:

"In conclusion, I believe that the fluid process, *i. e.*, the Bessemer and open-hearth, with the basic dephosphorizing improvement, will in time supersede all others for the production of iron and steel, and will ultimately enable the United States to become the greatest exporter of iron and steel in the world."

All the Bessemer steel companies in the United States have engaged to pay Mr. Reese a royalty under the basic dephosphorizing process.

THE CYANAMIDE COMPOUNDS OF SUCCINIC ACID.

By DR. H. MOLLER.

SUCCINIC acid forms with cyanamide three compounds corresponding to those formed with ammonia, succincyaminic acid, succincyanamide, and succincyamide. Succinic anhydride with potassium cyamide either in alcoholic or watery solution forms potassium succincyaminate. Succincyaminic acid, like succinamic acid, is easily decomposed. It is a strong bibasic acid, and forms two series of salts, among which the author describes those of potassium, barium, calcium, and silver. By the action of succinic acid chloride upon cyanamide in absolute ether, free from alcohol and water, there is formed succincyanamide along with cyanamide hydrochlorate. Succincyanamide, like succinamide, is decomposed by water into succincyaminic acid, and by alcohol into ether-succincyaminic acid. Sodium cyamide and ethyl oxide succinate in alcohol yield succincyamide sodium. Sodium cyamide and succinic acid chloride yield sodium chloride and sodium succincyamide. Succincyanamide melted with cyanamide yields succincyamide. This last-mentioned body is an acid and behaves more like cyanamide than succinamide.

CURIOUS OPTICAL ILLUSION.

A CORRESPONDENT of *La Nature* communicates to that journal the following description of a curious optical illusion:

Take a roll of paper about eight or ten inches long, and holding it in the left hand, apply the end to the right eye, as shown in the accompanying cut. With both eyes wide open look at some object—a small statuette, for example—a few feet distant. It will seem as if the right eye, looking through the paper tube, does not see the object at all; but, on the contrary, as if the right eye does see it, and that too through

EXPERIMENT SHOWING AN OPTICAL ILLUSION.

an orifice in the left hand. The left hand, which holds the cylinder, will seem to be very clearly pierced, and will have the appearance shown in the upper of the two figures. If the paper cylinder be held in the right hand and a small square of paper having a black circle in the middle be held against the external surface of the tube on the side to the left, the circle will appear to be suspended within the tube, at the center.

THE GYROGRAPH.

THIS apparatus, designed to facilitate the drawing on paper of arcs or circles of large radius, is the invention of Mr. Nicolas, an engineer of Lyons, France. Hitherto when draughtsmen have had to draw curves of so long a radius that compasses could not be employed for the purpose, they have generally been accustomed to use a series of wooden rules cut to fit arcs of circles of various radii. The difficulty of having constantly at one's disposal a large enough number of these rules suitable for all occasions, the high price of a complete set of them, and finally the imperfection that these often exhibit in their curves, induced Mr. Nicholas to design an instrument which should permit of the drawing not only of the curves given by the above mentioned rules, but also those of intermediate and varying radii. The apparatus, which is represented herewith, consists: (1) Of a series of pairs of articulated triangles, A A A,

THE GYROGRAPH.—THE INSTRUMENT OPEN AND CLOSED.

whose homologous summits, in any position whatever of the instrument, terminate in the circumference of a circle; (2) of a steel spring, R, which rests on the projecting points of the triangles and serves as a ruler for drawing the circumference so formed; (3) of two guides, G G, placed at the extreme points of contact of the spring and designed for preserving the curve of the latter to the surfaces of contact of these guides with the spring, being kept constantly pointed in a direction tangential to the projecting points of the triangles by means of two rods, *t t*, furnished with slots; (4) of two spiral springs, B B, located at the extremity of the steel spring, for the purpose of keeping the latter closely pressed against the summits of the triangles; and (5) of a ruler, *r*, designed for guiding the extreme parts of the articulated system and regulating its spread. A set screw, V, serves for keeping the instrument at a definite curve, whose radius is read on the graduated ruler. The instrument is also provided with a regulating screw, *v*, by means of which minute changes of curve may be made, and the radius indicator, I may be placed with precision on any given division. It is easy to see that if the spring is properly curved and well tempered, its curvature will be strictly circular since all the points upon which it rests form a regular polygon and are very close together. It will be also seen that the length of the spring included between any two of the consecutive points is not constant, since these points approach each other as the radius of curvature diminishes. Hence the necessity of fixing the spring at a single point in the middle by the rod, K, and of guiding the extremities only. The guides employed by the inventor have plane faces of contact and of a certain extent, rendering necessary a displacement of direction of these faces when the radius of curvature of the instrument varies. The dimensions of the triangles have been determined by Mr. Nicolas in such a way as to reduce as much as possible the play of the spring; that is to say, the variation in length of the part comprised between the extreme points of contact. When the instrument passes from the rectilinear to a circular form, the distance of any two consecutive points of contact will diminish, thus tending to reduce the length of that part of the spring comprised between these two points. But, on another hand, the curvature given to the spring increasing its length between the two same points, it is possible, as may be seen, to create a compensation between these two effects of elongation and shortening. The initial separation of the points of compaction has been chosen in such a way as to obtain this compensation when the apparatus has an extreme curve.

This instrument, which is entirely new, and very ingenious, appears to solve the problem for which it was designed in a very satisfactory way. It may be objected that it is somewhat heavy, but such a defect may be easily remedied by reducing the weight of the articulated triangles. The apparatus will probably meet the ready approbation of all draughtsmen and quickly come into use in their offices. At all events, the principle on which the instrument is constructed may possibly serve as a type for something which shall be still better.

ALABAMA COAL AND IRON.

PREPARATIONS are making for the construction of a railway from New Orleans to the coal and iron regions of Alabama, which have been left undeveloped for lack of a railway communication. A prospectus of the company furnishes the following information:

Alabama has a mineral territory of 4,300 square miles, chiefly of red and brown hematite and fossil iron and bituminous coals, said to be the richest in America, containing a little more sulphur than phosphorus, but not enough of either to be detrimental in manufacturing. The great coal beds are in Tuscaloosa, Walker, Winston, and Blount counties. Red fossil iron ores of excellent quality are in beds of five to six feet in thickness, and often cropping out at the surface. Limestone and fire clay are abundant, and all the elements needed in manufacture are to be had in a circle of from three to five miles. The iron in Shelby county is red and brown hematite. Here the coal is a greater distance from the iron, but charcoal is much used by manufacturers. The whole country is almost a vast region of yellow pine, which produces good coals when properly charred.

The red or fossiliferous ore is now known to exist almost without interruption from a point two miles and a half below Pratt's Ferry, in Bibb county, to the upper end of Will's Valley, De Kalb county, and in the east in Cherokee county to its northern part. On the west it runs up to Murphree's Valley. The thickness is variable, being in some localities twenty to thirty feet, and in others running down to one foot.

Northeast of Greensboro, and on the northwest side of the Read mountains, a bed occurs ten feet in thickness. Southeast of Elyton the ore continues for a distance of three miles; it caps the mountain and is fifteen feet in thickness. About Trussville, beds of brown hematite occur not far from the red ore beds. On the spurs of Cedar mountains red ore is found with numerous joints of crinoidal fossil stems, hence the name "buttons rock" applied to the ore. In St. Clair county, southwest of Springville, the ore occurs in a stratum fifteen feet thick, but varied in quality, in different parts of the bed. At Parson's Mills, in the same county, the ore is about seven feet thick, and is composed of large glazed grains.

In Murphree's Valley the ore is found in a bed of seven to eight inches in thickness. There is also a bed of brown hematite near this locality, one mile in length, composed of irregular masses. At Hanbie, on Turkey Creek, there is a bed of this ore which is a continuation of the Murphree's Valley ore. It is about twenty inches is thickness, and is found on the side of the ponds.

The examinations of the coal mines of Alabama have been limited and confined principally to the more accessible and settled parts of the State. The Great Warrior coal beds are favorably circumstanced for mining, the slight inclination of their beds and the physical features of the country will always tend to lessen the expense of mining on the Warrior. Considerable quantities of coal are procured from the beds of the stream, or where it is but slightly covered by loose superficial beds. The Cahawba fields have great inclination in their beds, and but little coal can be taken from the crop; mining must be adopted from the commencement, which requires some outlay in the sinking of shafts, and machinery for raising coal and water.

It seems that these coals are well adapted for the manufacturing of illuminating gas. An experiment made upon the small scale with eight pounds of Tuscaloosa coal (Simm's bed), which was distilled in a common iron mercury bottle—a very imperfect apparatus for the purpose—yielding thirty-two cubic feet of good quality; a very large amount in view of the necessary wasteful manner in which the process was conducted.

Iron ore, coal, limestone for fluxing, and fire-clay for furnaces, being in close proximity, furnish opportunities for profitable investment seldom to be found in any other State of the Union, requiring nothing but railroads to furnish

markets; and the sections destitute of roads are the most profitable localities for investment.

The immense quantity of coal consumed each year renders the question of its cheapness a very important one. There is no means of ascertaining definitely how much coal is consumed in Alabama annually, for the reason that large quantities of which no account is preserved are sent direct from Pittsburg, Pa., and from other points to plantations along the bayous tributary to the Mississippi River, and used for sugar manufacturing. The consumption of coal is greatly on the increase, and the fluctuation of prices is so marked that the question of regulating them by means of necessary and constant receipts is one of the most important questions now under public consideration.

As the distance from the Alabama coal beds to New Orleans is only about two hundred and fifty miles, coal can be loaded at the mines one day and delivered the next.

CITY SUPPLIES OF CHARCOAL.

THE charcoal used in New York and Philadelphia comes very largely from the southern counties of New Jersey. In an extended description of the charcoal business as carried on in that State, the Philadelphia *Public Ledger* says that 200,00 bushels are consumed in that city every year.

The burners of charcoal, living from twelve to twenty miles from the ferry, make from two to three trips a week to the city with their wagons. A two horse wagon load is about 50 barrels, or 125 bushels. Those living beyond this distance generally dispose of their products to the mills making granulated, pulverized, and bolted charcoal, to which it is conveyed in cars. The principal mill of this character, and said to be the oldest concern of the kind in the United States, is that of Charles Wright, at Berlin, Camden county, established by Thomas B. Wright, grandfather of the present proprietor, in 1831. At this mill is made ground charcoal for distillers and other uses, and the granulated article for chemical purposes. The charcoal is not merely ground and treated for these purposes, as most people suppose, but the raw lump or stick coal is placed in kilns, of which there are 22 at this establishment, holding 100 bushels each, and fire applied and continued until all the gases and vapor are dissipated, reducing the quantity nearly three-fourths. The residuum is then transferred to a mill operated by steam, where it is ground and broken to the proper size and consistence. The kilns in use for the above purpose are of brick and of a conical shape. The works have a capacity of about 300 bushels of the prepared material a day.

The advance of agriculture and the continued demand for pine wood for fuel are slowly but surely driving the charcoal burning into the background, yet, it is claimed, the use of charcoal is increasing, and it appears that the manufacturers of the article are managing to keep nearly abreast of the demands. Since the opening of the two new railroads to Atlantic City the manufacture of charcoal in their vicinity has largely increased. Charcoal from pine wood is the chief kind made in South Jersey, though oak is used to a large extent. It is finding an increased demand in hotels where a quick, clear fire is needed. Its uses in other occupations are well known. Oak charcoal is made chiefly in Pennsylvania, and is used in making iron and refined steel and laundry facings. Its cost is much greater than pine coal. Willow charcoal has its place of manufacture in Delaware, and is a material in making gunpowder and dentrifices.

The manner of making charcoal is as follows: A convenient spot in the midst of a timber forest is selected and a solid, conical shaped mound, about nine feet high, made of two lengths of wood placed perpendicular with an inclination to the center. The pyre is then covered several inches thick with sod and loam, and made perfectly air-tight. Fire is introduced through air-holes made around the base of the mound and allowed to smoulder for ten days or until all watery and other volatile matter has been expelled by heat. During the process of combustion constant watchfulness and care are necessary to prevent the admission of air enough to ignite the wood. Six cords of wood constitute an average burning, the result being from 100 to 150 bushels of charcoal. Dead timber, caused by forest fires or age, or other causes, will not make charcoal.

The manufacture of wood into charcoal is somewhat more profitable than converting it into firewood, as the wood can be used up more closely. A score or more years ago charcoal could be bought at the kiln for five cents a bushel, and from the wagons for twenty five cents a barrel. The price is now double in both instances.

Last winter and early the present spring the price of charcoal at the kiln was as high as twenty-five cents a bushel. This extraordinary increase in price was owing to the deep snow and frozen ground, which prevented the burners from digging the earth necessary to cover their kilns. The operation of making charcoal is carried on all the year round, the condition of the wood at the different seasons of the year not affecting the coal.

THE NATIONAL WEALTH.

THE total valuation of the national wealth of this country, as compared with that of other nations, as given by Mr. T. M. Coan in a recent number of *Harper's Magazine*, is as follows: We stand near the head of the list—third on the list of all the Western nations. The United Kingdom of Great Britain and Ireland heads the list with a capital valuation of $44,400,000,000; then comes France with $36,700,000,000, the United States with $32,000,000,000; Germany with $22,000,000,000; Russia with $15,000,0 0,000, and the Low Countries with $11,150,000,000 of capital, collectively. These are the valuations made by those countries of their entire resources. What is the average annual income per inhabitant in various countries? We come to the front in this comparison. The average annual income in the United Kingdom is $165; in the United States, $165 also; in the Low Countries, $130; in France, $125; in the British Colonies, $90; in Germany, and also in Scandinavia, $85. In this reckoning Russia, with her ninety millions of people, is out of sight as yet; she will not be very long. On the score of annual accumulation our case is even better, relatively far better. The annual accumulation of wealth in Germany is $200,000,000; it is $325,000,000 in the United Kingdom; $375,000,000 in France; in the United States it is $825,000,000! Our increase of national wealth, since 1850, says a good English authority, would be enough to purchase the whole German Empire, with its farms, cities, banks, shipping, manufactures, etc. The annual accumulation has been $825,000,000, and therefore each decade adds more to the wealth of the United States than the capital value of Italy or Spain. Every day the sun rises upon the American people it sees an addition of $2,300,000 to the wealth of the Republic.

INTERESTING POSTAL STATISTICS.

A STATEMENT has been prepared at the Post-office Department by the committee appointed to conduct the official count, showing the amount of matter mailed in the United States during the year ending December 31, 1880. The total number of pieces of all classes mailed during the year was 2,720,234,252. The whole number of letters mailed during the year was 1,053,252,876, or an average of 21 for each man, woman, and child in the United States. 324,556,440 postal cards, 812,032,000 newspapers, 40,148,792 magazines and other periodicals, and 21,515,832 packages of merchandise passed through the mails during the year.

The following table shows the number of letters mailed in each of the States and Territories, and the average number mailed by each person:

Names of States and Territories.	Number.	Average Mailed by Each Person.
Alabama	8,894,376	7·04
Alaska Territory	6,812	0·22
Arizona Territory	1,278,420	31·61
Arkansas	6,419,296	7·99
California	22,563,268	26·09
Colorado	10,749,024	55·22
Connecticut	27,789,376	38·20
Dakota Territory	4,023,708	29 76
Delaware	2,384,928	16 26
District of Columbia	15,154,620	85·31
Florida	3,071,276	11·48
Georgia	14,607,216	9 49
Idaho Territory	825,812	25 32
Illinois	68,643,328	22·29
Indiana	25.574,536	12·97
Indian Territory	465,452	6·05
Iowa	28,984,592	17·84
Kansas	18,380,908	18·45
Kentucky	14,571,008	8·84
Louisiana	13,782,184	14·68
Maine	13,245,696	20·36
Maryland	16,475,732	17 62
Massachusetts	69,070,604	38·70
Michigan	32,928,896	20·12
Minnesota	16,742,440	21·44
Mississippi	7,265,544	6·42
Missouri	39,702,208	18·30
Montana Territory	1,576,824	40·25
Nebraska	10,291,320	22·74
Nevada	1,963,884	31·54
New Hampshire	7,698,548	22·18
New Jersey	20,783,048	18·37
New Mexico Territory	1,584,700	13·38
New York	211,435,640	44·58
North Carolina	8,137,042	5·81
Ohio	61,464,052	19·21
Oregon	3,636,880	20·80
Pennsylvania	105,237,340	24·57
Rhode Island	7,174,960	25·94
South Carolina	7,2'5,276	7·23
Tennessee	11,262,784	7·30
Texas	18,723,046	11·75
Utah Territory	2,796,040	19·42
Vermont	7,058,688	21·24
Virginia	16,874,104	11·15
Washington Territory	1,141,452	15·19
West Virginia	4,912,492	7·94
Wisconsin	22,765,912	17·30
Wyoming Territory	880,568	42·35

NEWARK, NEW JERSEY, AS A MANUFACTURING CENTER.

THE manufacturers of Newark, New Jersey, turned out last year products valued at nearly $67,000,000. The number of operatives employed was 41,510, who received as wages close upon $15,000,000. Of twenty distinct classes of manufactures, the year's output exceeded $1,000,000. They were as follows:

NAME OF BUSINESS.	No. of Hands.	Total Amount of Wages paid.	Total Value of Products.
Leather	2,661	$1,413,712	$10,440,992
Gold, silver, and metal refining	342	170,100	8,794,600
Jewelry	2,535	1,094,016	4,632,827
Malt and malt liquors	53[illegible]	329,8[illegible]0	4,508,707
Hats and caps	2,955	867,02[illegible]	2,262,894
Cotton, woolen, and silk goods	1,861	565,94[illegible]	2,212,250
Trunks, bags, and frames	1,567	570,522	2,138,923
Clothing, men's	1,438	472,947	2,055,108
Wholesale boots and shoes	1,535	575,984	1,886,504
Slaughtering and meat packing	120	57,510	1,653,016
Machinery	1,167	567,391	1,630,077
Saddlery hardware	1,217	410,636	1,496 008
Building	2,034	464,510	1,409,974
Chemicals	463	193,150	1,4[illegible]2,880
Fertilizers	580	245,000	1,400,000
Celluloid	750	242,498	1,251,540
Harness	833	272,793	1,197,204
Sewing machines, repairing, etc.	1,012	602,000	1,062,500
Rubber, enameled and oil-cloth	257	115,227	1,039,040
Iron and steel	629	185,933	1,014,023

AMERICAN BUTTER IN ENGLAND.

THE London *Grocer* referring to our creamery butter factories, which exist now in all parts of the country, predicts that they will soon revolutionize the American butter trade, and will bring an enormous quantity of fine butters on the English markets. It will give a great impetus to direct trading with America, as the quality of creamery butter is now well recognized. The Americans display a keen perception of the possibilities of the future when they thus evince their determination to fight butterine on the only ground it can be resisted upon, that of quality. They intend surrendering altogether to it the low-quality butter trade, and in doing so they are only prudently retiring from ground they would ere long be forced to abandon in retreat. It would be well if our Irish producers, adds the *Grocer*, would take the lesson thus given, and follow the good example. Those who control the Irish butter trade will want to open their eyes now, and try to see what is before them. They must improve both the manner in which Irish butter is manufactured and sent to market; they must put down the practice of over-salting and adding too much water. America never does anything by halves, and, if the weather does not intervene, we believe the immense quantity of fine butter which it will send to this country this year will have a very serious effect on the price of Irish butter, no matter how the quality of the latter improves.

THE GREAT WALL OF CHINA.

THE great wall of China was measured in many places by Mr. Unthank, an American engineer, lately engaged on a survey for a Chinese railway. His measurement gives the height at eighteen feet, and a width on top of fifteen feet. Every few hundred yards there is a tower twenty-four feet square, and from twenty to forty-five feet high. The foundation of the wall is of solid granite. Mr. Unthank brought a brick from the wall, which is supposed to have been made 200 years before the time of Christ. In building this immense stone fence to keep out the Tartars, the builders never attempted to avoid mountains or chasms to save expense. For 1,300 miles that wall goes over plain and mountain, and every foot of the foundation is in solid granite, and the rest of the structure is solid masonry. In some places the wall is built smooth up against the bank, or canyons, or precipices, where there is a sheer descent of 1,000 feet. Small streams are arched over, but in the larger streams the wall runs to the water's edge, and a tower is built on each side. On the top of the wall there are breastworks, or defenses, facing in and out, so the defending force can pass from one tower to another without being exposed to the enemy from either side. To calculate the time of building or cost of this wall is beyond human skill. So far as the magnitude of the work is concerned, it surpasses anything in ancient or modern times of which there is any trace. The pyramids of Egypt are nothing compared to it. —*London News.*

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